"NATURE". MAY 27. 1961
SUPPLEMENT: RECENT SCIENTIFIC AND TECHNICAL BOOKS

NATURE

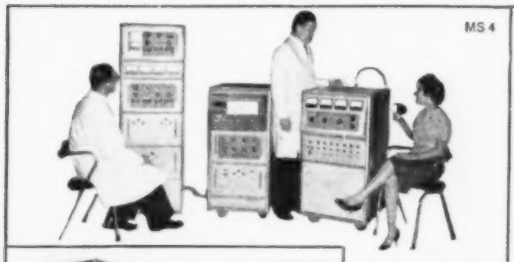
A Weekly Journal of Science

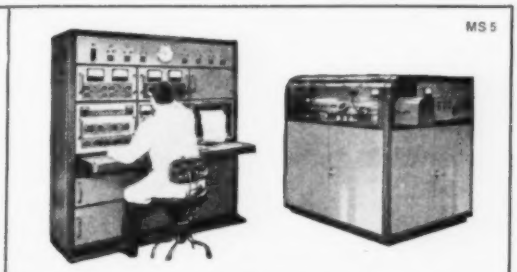
Vol. 190, No. 4778 SATURDAY, MAY 27, 1961 2s. 6d.

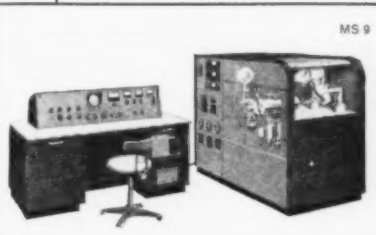
AEI

MASS SPECTROMETERS

The largest range in the world!







TYPE	APPLICATION
MS 2-G	Chemical/isotopic analysis of gas/volatile liquid samples up to mass 450.
MS 2-H	Chemical analysis of gas/liquid/solid samples of high molecular weight.
MS 2S	Isotopic analysis of solids using surface ionization.
MS 2-SG	Isotopic analysis of solids/gases.
MS 3	Chemical/isotopic analysis of gases/volatile liquids.
MS 4	Respiratory gas analysis and applications requiring continuous analysis and display of up to four components simultaneously.
MS 5	Routine isotopic analysis of solids using surface ionization.
MS 7	Chemical analysis down 0.001 p.p.m. using spark source techniques.
MS 9	Chemical analysis and structural identification of compounds up to mass 2,000.
MS 10	Simple spectrometer for vacuum monitoring and gas analysis up to mass 100.
LD 1	Leak detection using helium, argon or coal gas as probe medium.

Full details of all these types of equipment available from:

AEI Instrumentation Division, Scientific Apparatus Department, Trafford Park, Manchester, 17.

AEI

Instrumentation Division, Associated Electrical Industries Limited

SC/125

"SPEEDIVAC"

... range of high vacuum pumping accessories gives vacuum engineers an exceptionally wide choice of interchangeable standard components. This provides a unique opportunity for a flexible design approach to the construction of really practical vacuum systems.

(top) Stainless steel quarter swing butterfly valve.
(centre) Stainless steel cold trap.
(bottom) In line or right angle water-cooled isolation or baffle valve.

EDWARDS HIGH VACUUM LTD | MANOR ROYAL | CRAWLEY Crawley 1000 | SUSSEX | ENGLAND

NUTRITIONAL BIOCHEMICALS CORPORATION
21010 Miles Avenue
Cleveland 28, Ohio

Send for our free February, 1961 Catalog containing more than 2600 items. Fill out coupon and mail today for your copy.

Name.....
Organization.....
Address.....
City.....
State.....Zone.....
(N)

Are you measuring VIBRATION, EXPANSION, or DIMENSIONS OF PLIABLE OR INACCESSIBLE OBJECTS?
The most simple and economical solution to your problem is possibly illustrated on this page.

FOR MEASURING MICROSCOPES

UNIVERSAL MEASURING MICROSCOPE and CATHETOMETER

Range 50 cm. Can be used in three different planes as a cathetometer (focus: 15" to infinity) or a microscope (focus: 1⅛"). 360° rotation on the heavy levelling base. Vernier scales read to 0.05 mm. over entire range of 50 cm. and 00.1 mm. over any selected range of 25 mm.

CAT. NO. 6147

TWO-DIMENSIONAL MEASURING MICROSCOPE

An extremely accurate method of measuring in two horizontal directions at once. Range 20 cm. x 10 cm. Direct reading to better than 0.01 mm. Supplied with cabinet.

CAT. NO. 6164

UNIVERSAL MEASURING MICROSCOPE AND CATHETOMETER

Range 30 cm. Very similar to cat. no. 6166 but fitted with fixed base without spirit levels. Supplied with cabinet.

CAT. NO. 6166

The NEW Pye range of measuring microscopes and cathetometers is designed to cater for numerous measuring applications in research and industry. Each instrument can perform several different functions with high accuracy, and new design features make operation fast and simple.
Either Metric or English calibrations can be specified.
Quality of craftsmanship and materials are of the highest standard yet careful design has resulted in a very competitive price level. Please ask us to send you descriptive leaflets.

"ACCURACY OF CALIBRATION AND ENGRAVING OF THESE INSTRUMENTS TO B.S. 887"

CAT. NO. 6192

PRECISION CATHETOMETER

Range 100 cm. For vertical use as a cathetometer or measuring microscope. 360° rotation of telescope. The heavy levelling base is fitted with sensitive levels.

CAT. NO. 6150

TELESCOPE/MICROSCOPE KIT

Contains components which make up a telescope (focus: 15" to infinity) and microscope (focus: 1⅛") fitted with spirit level and slow-motion focusing. For use with cat. nos. 6164, 6166 and 6192.

SCIENTIFIC PYE INSTRUMENTS

W. G. PYE & CO. LTD.

GRANTA WORKS, P.O. BOX 60, CAMBRIDGE, ENGLAND
Telephone: CAMBRIDGE 58866 (5 lines) Telegrams: PYE CAMBRIDGE

BEA

CHOOSE

VANGUARD

The outstanding characteristics of the new "Vanguard" are extremely low running costs, and large capacity. As a result, BEA have calculated the "passenger cost per mile" will figure lower than any other aircraft.

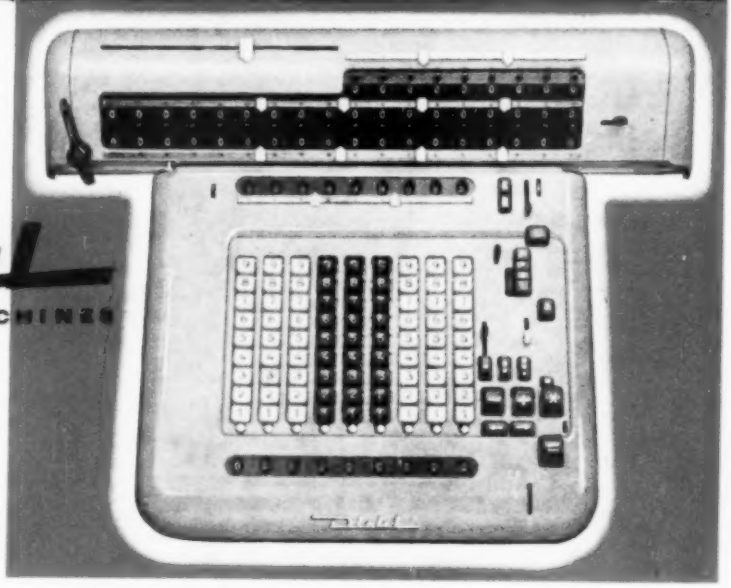
BEA

CHOOSE

Diehl

CALCULATING MACHINES

FOR HIGHEST POSSIBLE OUTPUT ACCURACY & VALUE



Costing the Vanguard's operation is being done by BEA on Diehl Calculators because:

1. Diehl's unique short cutting action gives an output rate and life factor higher than that of any other desk calculating machine.
2. Diehl are silent and dependable in operation and easy to maintain. If ever BEA require service, they get it within one hour.
3. Diehl Calculators always give the right answer. All models have complete transmission, even the least expensive.
4. BEA, like Archimedes-Diehl Machine Company Limited, are a progressive commercial organisation and they always choose the most up-to-date equipment.

Follow the example of BEA and other leading organisations. Be in the vanguard and see the NEW Class V

Diehl

RANGE OF CALCULATORS

ARCHIMEDES-DIEHL MACHINE COMPANY LTD.

Chandos House, Buckingham Gate, London, S.W.1. Telephone: ABBey 2014

SALES AND SERVICE THROUGHOUT THE COMMONWEALTH

the ONLY low impedance multi-voltage reference source

simplifies instrument calibration

This versatile voltage standard is ideal for use wherever an extremely stable DC voltage reference source is required—pH testing; bias circuits; speed, temperature and voltage measurement; thermistor bridges; control and telemetering systems.

Rugged non-glass construction withstands brief short circuits, severe vibration, physical shock. Operates in any position. Fully portable in leatherette carry case.

Low impedance—only ½ to 1 ohm per cell.

Accuracy ±½% of stated open circuit voltage.

Stability—within 1% from −20°F to +160°F.

Long life Guaranteed for 2 years.

The Mallory Reference Battery is available in two sizes—as a multi-volt battery with 8 outputs from 0–10·80 volts in 1·35 volt increments, or as a single cell 1·35 volt battery.

Supplied by
BAIRD & TATLOCK (LONDON) LTD
Chadwell Heath, Essex
A. GALLENKAMP & CO LTD
Technico House, Sun St, London EC2
W. B. NICOLSON (Scientific Instruments) LTD
Thornliebank Industrial Estate, Glasgow, Scotland
J. W. TOWERS & CO LTD
Victoria House, Widnes, Lancas ire

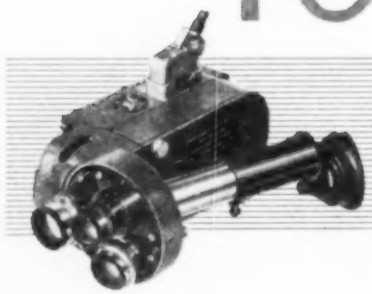
Price Multi-volt £10.
Single Cell £4.
Delivery ex-stock.

For detailed specifications write for Bulletin 1-209

MALLORY BATTERIES LTD Rainham Road South Dagenham Essex

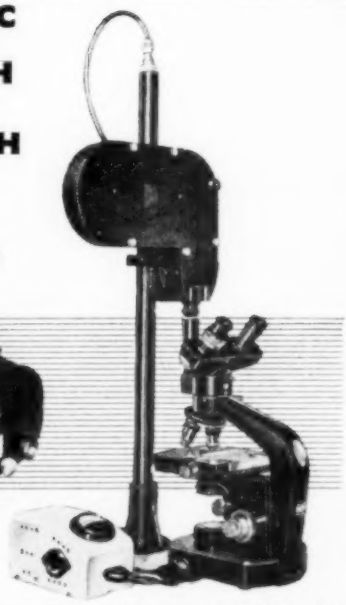
Vinten 16 mm

SCIENTIFIC RESEARCH AND HIGH SPEED CAMERAS



Mk. II Scientific Camera with triple lens turret and rotating mirror reflex shutter. For 8, 16, or 24 f.p.s. or single shot operation.

16 mm. High Speed Camera up to 250 f.p.s. with timing device giving accurate visual time scale on film and event marker.



Mk. I Research Camera with extended exposure facility which enables lengthy microscope observations to be left to the camera. Battery or mains operation. 8, 16, 24 f.p.s.—or single shots by intervalometer.

Information about Vinten scientific cameras and their uses in Research and Industry are contained in two booklets which we should be pleased to send on request.

W. VINTEN LTD., NORTH CIRCULAR ROAD, CRICKLEWOOD, N.W.2. GLADSTONE 6373

For Ribonuclease Assay...use
WORTHINGTON RIBONUCLEIC ACID

Purified from yeast by the method of Crestfield, Smith and Allen,

For information write:

WORTHINGTON BIOCHEMICAL CORPORATION

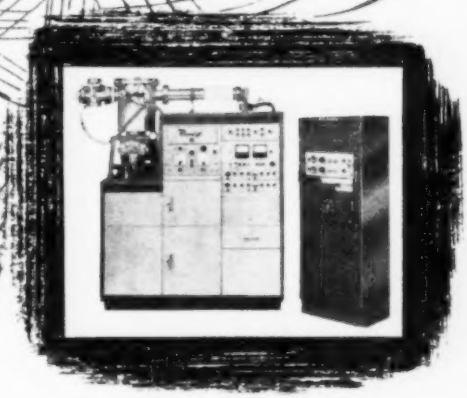
FREEHOLD 19, NEW JERSEY

worthington

Phosphodiesterase Substrate! Use
WORTHINGTON RNA CORE

prepared as described by Hilmoe

Bendix TIME-OF-FLIGHT MASS SPECTROMETER



SPEED 10,000 complete mass spectra each second.

SENSITIVITY Accurate detection at 5 ppm level.

RESOLUTION Mass range m/e 1 to 5000; unit resolution to m/e 200.

HIGH PUMPING SPEED 100 to 125 litres per second at ion source.

EASY MAINTENANCE Plug-in modular electronics chassis. Instrument in single cabinet.

OUTPUT All machines fitted with Analogue Output System. Up to 6 channels for simultaneous recording available, plus conventional oscilloscope reading.

INLET SYSTEMS V.P.C.; Molecular Leak; Integral Fast Reaction Chamber; Hot Filaments Inlet; Knudson Cell Inlet.

Field's

U. K. Distributors, service and installation specialists:—

FIELD AIRCRAFT SERVICES LTD

Ancillary Division, London Airport, Hounslow, Middlesex · Telephone: Skyport 2141 · Cables: Fieldair London Airport

The New Brunswick Scientific Company Presents The PsycroTherm(TM)

A CONTROLLED-ENVIRONMENT INCUBATOR-SHAKER

Patent Pending

PsycroTherm can be used as an Incubator, Shaker, Environmental Chamber, BOD Incubator, Refrigerator

For the Growth of Microorganisms under Controlled Conditions of Temperature, Atmosphere, and Agitation

THE PSYCROTHERM is a rigidly controlled environmental incubator with a continuous-duty shaking mechanism. Though it occupies comparatively little floor area, it has 10½ cubic feet of *usable* work space in the incubation chamber, where static and shake cultures can be incubated simultaneously or separately.

A VERSATILE UNIT

With fully integrated heating and refrigeration systems the unit is ideal for work with psycrophilic, mesophilic, and thermophilic systems. Temperatures can be accurately regulated from 0° C to 60° C with a control tolerance and temperature gradient both within ± 0.5° C. In non-refrigerated units, the temperature range is from ambient to 60° C, with the same tolerance and gradient as above.

There are many interchangeable shaker platforms. They have large capacities for flasks, tubes, and other culture and reaction vessels.

CHOICE OF SHAKER MECHANISMS

The degree of agitation can be selected and the temperature controlled for the growth of aerobic and anaerobic organisms. Models are available with either Gyrotory® or reciprocal agitation, and illumination for photosynthesis studies. The PSYCROTHERM can also be used as a BOD incubator.

CONTINUOUS DUTY SHAKING

The shaking mechanisms are precision built for continuous operation, long life, and for smooth, quiet, reproducible agitation. Speed is adjusted mechanically and will never drift nor vary when workloads or voltages change. The rotary shaker mechanism has a range of speeds between 50 rpm and 400 rpm. The reciprocating shaker mechanism has an adjustable stroke from 0 to 3½" and a speed range between 40 and 285 oscillations per minute.

OVERALL DIMENSIONS: Width 40", Depth 29", Height 65"
CHAMBER DIMENSIONS: Width 32½", Depth 21", Height 26"

UNCONDITIONAL ONE-YEAR WARRANTY

Write for Catalog G26S/ N51

NEW BRUNSWICK SCIENTIFIC CO., INC.
PRECISION LABORATORY APPARATUS
P.O. BOX 606, NEW BRUNSWICK, NEW JERSEY

GRINDING, MIXING
in our unique AGATE MACHINES

- NO CONTAMINATION
- SAVES TIME
- SAVES MONEY

For use with Electron Microscopy, Infra-red Spectroscopy, X-ray Diffraction Studies, Powder Metallurgy; also applications in Biochemistry, Agricultural and Horticultural Research and Preparation of Research Materials.

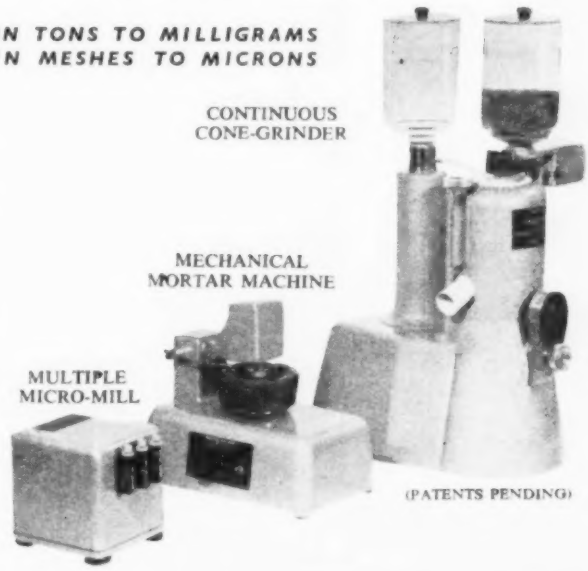
Also for Production, in mines and factories.

We are long-established makers of DIAMOND METAL BONDED SAWS, GRINDING WHEELS and CORE DRILLS made to any required dimensions and uses.

Over a century of stonecutting experience

AGATE & GENERAL STONECUTTERS LTD.
25 HATTON GARDEN, LONDON, E.C.1, ENGLAND
Phone: EDGware 2558

IN TONS TO MILLIGRAMS
IN MESHES TO MICRONS

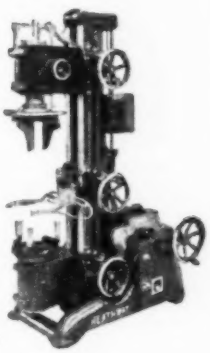


(PATENTS PENDING)

Heathway
Glass Working Lathes

are known throughout the world

- 5 types available
- May we send you leaflets?



The new universal model in its vertical position

HEATHWAY MACHINERY CO. LTD.
UXBRIDGE ROAD, HILLINGDON, MIDDLESEX
TELEPHONE: UXBRIDGE 6345

Agents in the U.S.A. and France
Richoux Co. Inc., 1133 Broadway, New York 10, N.Y.
Ets. L. Richoux, 22 Cité Trévise, Paris 9e

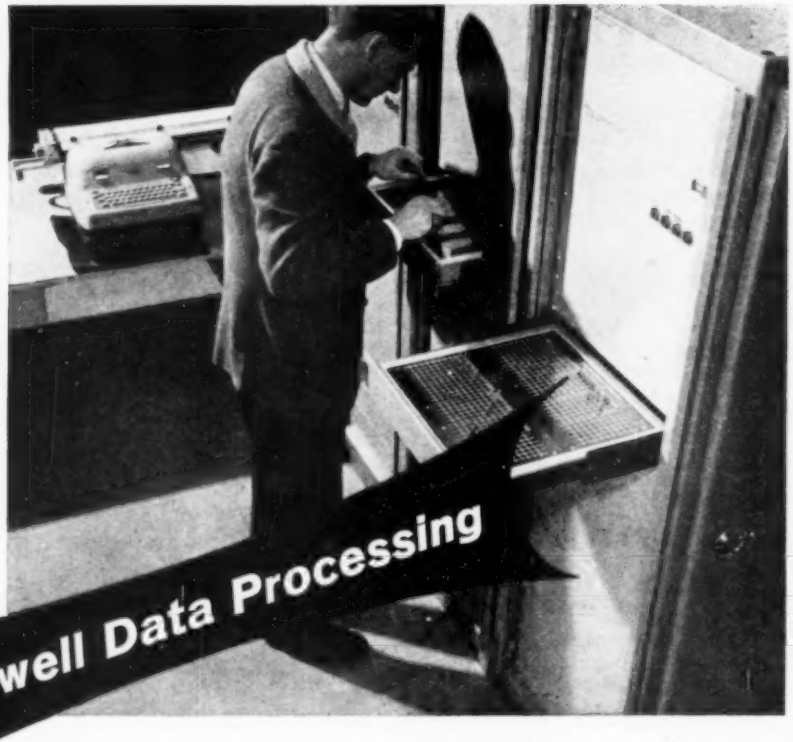
GLASS

All Glass Requirements for Scientific Instrument Manufacturers and Research Workers

- SHEET & PLATE-GLASS—cut and ground to exact dimensions.
- LENSES, PRISMS & FLATS—to any standard of accuracy.
- MIRRORS—back silvered and front surface aluminised, etc.
- BLOOMING of optical components.

C. J. WHILEMS, LTD.
ILFORD OPTICAL WORKS
FOREST ROAD, BARKINGSIDE, ESSEX

Telephone: HAInault 5454-5



Honeywell Data Processing

for Industry and Research

Logging equipment, incorporating 'Pinboard Programming' at R.A.E. Farnborough

At the Royal Aircraft Establishment, Farnborough, a Honeywell three-bay data processing system with electric typewriter print-out is now logging:

139 temperature inputs in 3 ranges
0 to 99·9° C, 0 to 650° C, −50 to 300° C

96 pressure inputs in 4 ranges
0 to 20 p.s.i., 0 to 50 p.s.i., 0 to 200 p.s.i.,
0 to 500 p.s.i.

4 speed measurements
1 reference point

The equipment is based on the Honeywell Digital Potentiometer principle. It makes extensive use of mercury wetted relays and incorporates a unique feature—Pinboard Programming. Drawer-mounted pinboards add an easy flexibility to adjustments of span, zero suppression and alarm limit settings. Only a simple repositioning of pins is required to change these functions. Speed of operation, simple maintenance and continuous checks are other built-in advantages of this Honeywell system. It is suitable for research, industrial development and may also be used to supply information to computers. Annunciator panels, linearisation circuits and other features are available.

WRITE OR SEND THE COUPON TODAY to
Honeywell Controls Limited, Greenford, Middlesex. Waxlow 2333.

I am interested in Honeywell data processing (logging/scanning) equipment

for

Please send me Specification Sheets SS 396-1, SS 312-1

Name

Position

Company

Address

N

Sales Offices in the principal towns and cities in the United Kingdom and throughout the world.

Honeywell

First in Control

SINCE 1885

NATURE

No. 4778 SATURDAY, MAY 27, 1961 Vol. 190

CONTENTS

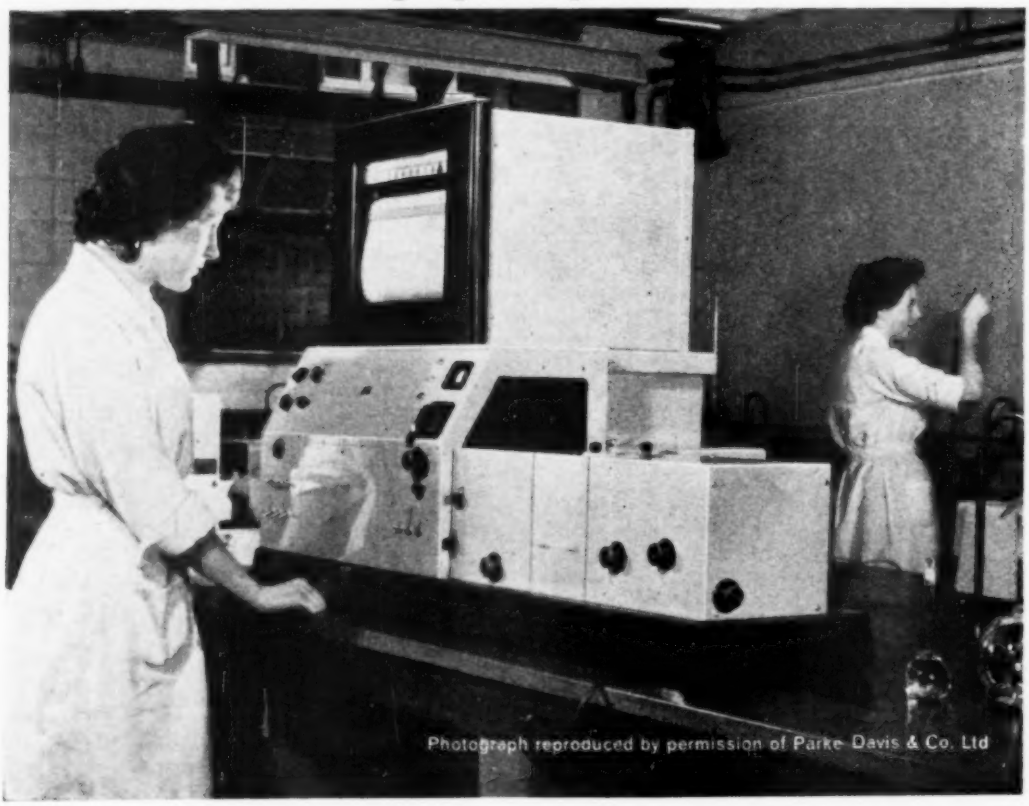
	Page
Academic Freedom in South Africa	747
Analysis of Agricultural Materials, Foods and Drugs. By H. V. Hart	749
Controlled Thermonuclear Reactions. By Sir Basil Schonland, C.B.E., F.R.S.	750
Carbohydrate Chemistry. By Dr. G. O. Aspinall	750
Human Nutrition. By Prof. J. Yudkin	751
Grassland Philosophy. By Prof. Ian Moore	751
Crystal Gazing. By Dr. A. D. Booth	752
Strontium-90 in Fall-out and in Man in Australia, January 1959–June 1960. By Dr. F. J. Bryant, L. J. Dwyer, D. J. Stevens, Prof. E. W. Titterton, C.M.G., and J. R. Moroney	754
L. Euler, the Principle of Relativity and the Fundamentals of Classical Mechanics. By D. Speiser	757
The Breeding of Improved Milking Cows through Artificial Insemination. By Dr. J. Edwards and Dr. L. K. O'Connor	759
Obituaries:	
Academician A. F. Joffe. By Academician N. N. Semenov, For.Mem.R.S., and Academician V. N. Kondratiev	761
Prof. C. W. Dannatt. By Dr. M. S. Fisher	763
Prof. J. Bordet, For.Mem.R.S. By Sir Samuel Bedson, F.R.S.	763
News and Views	764
Man and the Soil. By Dr. Kenneth Mellanby, C.B.E.	770
Solar Seeing. By Dr. R. G. Giovanelli	771
Tropical Ecology in India	772
The West African Rice Research Station. By H. D. Jordan	773
Technical Education in Wales. By Dr. P. F. R. Venables	774
Addiction-producing Drugs	775
Cultural Sequences in North-west America. By Dr. G. H. S. Bushnell	775
Total Magnetic Field Measurements between New Zealand and Antarctica. By Dr. D. A. Christoffel	776
Stagnation Temperature Measurements in a Hypersonic Wind-Tunnel using the Sodium Line Reversal Method. By J. L. Stollery	778
Formation of Helical Microfibrils from a Steroid Acid Complex. By Dr. N. Ramanathan, A. L. Currie and J. Ross Colvin	779
The Active Site and Mechanism of Action of Bovine Pancreatic Ribonuclease. By Dorothy Findlay, D. G. Herries, Dr. A. P. Mathias, Dr. B. R. Rabin and C. A. Ross	781
Visual Pigment of Grapsoid Crabs. By Michael H. Briggs	784
Contraction of Smooth Muscles in Non-ionic Solutions. By Roselyn L. Kolodny and Prof. W. G. Van der Kloot	786
Movement of the Ovum in the Reproductive Tract. By J. P. Bennett; M. J. K. Harper, J. P. Bennett and L. E. A. Rowson	788
Coprecipitation of Mitochondria and Chloroplasts. By Rachel M. Leech and Dr. R. J. Ellis	790
Induction of Heritable Respiratory Deficiency in *Saccharomyces* by Pantothenate Starvation. By Prof. Alvin Sarachek and Gregory L. Fowler	792
Radiosensitization of *E. coli* by Purine and Pyrimidine Analogues incorporated in Deoxyribonucleic Acid. By Prof. Henry S. Kaplan, Dr. Kendric C. Smith and Patricia Tomlin	794
Recent Scientific and Technical Books	Supp. viii

(Continued overleaf)

UNICAM

This is the SP.700 Spectrophotometer. One of the most advanced analytical instruments of its kind. Precise—versatile—reliable—made for analysis through a spectral range of Ultraviolet, Visible and Near Infrared. The SP.700 records a detail of the composition of unknown mixtures—detects minute traces of the most elusive elements—completes in minutes a task which would take hours or weeks by other methods. Used by scientists in the great University and Industrial Laboratories of the world. Made by Unicam Instruments Ltd., Arbury Works, Cambridge.

SP.700 Recording Spectrophotometer



UNICAM INSTRUMENTS LIMITED · ARBURY WORKS · CAMBRIDGE

LETTERS TO THE EDITORS

ASTROPHYSICS

Solar Flare Effects in the *F* Region of the Ionosphere.—R. W. Knecht and K. Davies . . . . . Page 797

PHYSICS

Effects of High Pressure on Glass: a Possible Piezometer for the 100-Kilobar Region.—Prof. Rustum Roy and H. M. Cohen 798

Estimation of Dynamic Modulus and Dynamic Yield Stress for 'Perspex'.—John Roberts 799

Packing of Spheres.—Dr. J. R. Parrish 800

GEOLOGY

Potassium-Argon Ages of the Dartmoor and Shap Granites using the Total Volume and Isotopic Dilution Techniques of Argon Measurement.—M. H. Dodson, J. A. Miller and D. York 800

Karroo Igneous Activity and Tectonics in South-East Southern Rhodesia.—D. N. Wood 802

CHEMISTRY

Sorption of Copper by Cellulose.—Dr. R. I. C. Michie; Prof. R. D. Preston, F.R.S. 803

The Borohydride Ion in the Lithium Borohydride Lattice.—Dr. D. A. Brown; C. J. H. Schutte . . 804

Chromium(III) Oxyanion Systems.—G. M. Lukaszewski and J. P. Redfern 805

Assurance of Thermostatic Control during Electrophoretic Experiments.—Dr. R. J. Wieme . . . 806

BIOCHEMISTRY

Quinine Oxidase in Liver and Blood Plasma of Rabbits poisoned with Carbon Tetrachloride.—Dr. Gilberto G. Villela 807

Isolation of the Toxic Principle in *Acacia georginae*.—P. B. Oelrichs and T. McEwan 808

Origin of β-Aminoisobutyric Acid in Iris.—W. R. Evans, Chi Shiun Tsai and Prof. Bernard Axelrod . 809

A Supplement to the Kober Reaction for Urinary Œstrogens.—Dr. L. Bradshaw 809

Controlled Use of Adsorbents in Enzyme Purification.—Dr. I. T. Oliver 810

The Pasteur Effect in a Respiration-deficient Mutant of Baker's Yeast.—A. Kotyk 811

Is *Mycobacterium phlei* Glutamotransferase endowed with Glutamine Synthetase Activity?—V. S. Halpern and Prof. Nathan Grossowicz 812

PHYSIOLOGY

Flow of Portal and Hepatic Blood in Normal and Cirrhotic Liver.—Dr. T. Nakamura, S. Nakamura and T. Kaneko 812

Purification of the Toxic Fractions from *Ascaris lumbricoides* and their Effect on the Guinea Pig.—G. Gazzinelli, M. M. Guia, A. G. A. Neves, J. Pudles, W. T. Beraldo and W. Dias da Silva 813

Cholinergic Activity of Hyoscyamine.—Prof. A. Teitel . 814

Serum Changes in the Rat following Oral Administration of Cadmium.—D. J. Lawford 815

Absorption of Amniotic Fluid in the Gut of Fœtal Sheep.—G. H. Wright and Dr. D. A. Nixon . . . 816

Spontaneous Potentials from Explants of Chick Cerebral Hemisphere (Telencephalon) in Tissue Culture.—Prof. A. W. B. Cunningham 816

RADIOBIOLOGY

Increase of Aldolase Activity in Blood Serum following Irradiation.—Dr. B. Dalos 817

Effect on Biological Nitrogen Fixation of Nitrogen Gas treated with Ultra-violet Radiation.—B. Zacharias and C.-G. Hedén 817

HÆMATOLOGY

Hæmoglobins of Fœtal *C57BL* 6 Mice.—J. Barrowman and M. Craig 818

PATHOLOGY

Anti-tumoral Action of New Sarcomycin Derivatives.—Prof. A. Caputo, B. Giovanella and R. Giuliano . 819

Reversible Nature of Liver Cell Damage due to Carbon Tetrachloride as demonstrated by the Use of Phenergan.—Dr. K. R. Rees and Dr. W. G. Spector . 821

Alloxan and Hypersensitivity.—Dr. George E. Thompson 822

ANATOMY

Function of the Fœtal Thyroid of the Rabbit with regard to Cholesterol Metabolism studied by Fœtal Thyroidectomy.—J. G. Bearn, H. B. Koerselman and T. R. E. Pilkington 822

BIOLOGY

Transport of Carbon in Fungal Mycelium.—Stella I. Thrower and L. B. Thrower 823

Prevention of Manganese Deficiency in Oat by soaking the Grain in Solutions of Manganous Chloride.—Donald S. H. Drennan, Alex. M. M. Berrie and Gordon A. Armstrong 824

Nucleic Acids and Sexual Differentiation in *Allomyces*.—Dr. G. Turian 825

Determination of the Volume and Weight of Living Animals.—Prof. C. P. Gnanamuthu 826

β Galactosidase Changes in the Developing Intestinal Tract of the Rat.—Dr. Anibal Alvarez and Jose Sas 826

Avian Schistosomes in Hertfordshire.—Dr. D. L. H. Robinson 827

Diapause, Neurosecretion and Hormones in Copepoda.—Dr. D. B. Carlisle and W. J. Pitman 827

Verification of the Gastropod Golgi Cycle with an Electron Microscope.—Prof. Leonard G. Worley and Betty Hershenov 828

A 'Natriferic' Principle other than Arginine-Vasotocin in the Frog Neurohypophysis.—F. Morel, J. Maetz, R. Acher, J. Chauvet and M. T. Lenci 828

Enhancement of Intraperitoneal Staphylococcal Virulence for Mice with Different Bile Salts.—Dr. S. Stanley Schneierson, Daniel Amsterdam and Ely Perlman 829

Paper Chromatography of Natural Saponins.—Dr. B. Pasich 830

MICROBIOLOGY

A Diurnal Cycle for Holotrich Protozoa of the Rumen.—D. B. Purser 831

Multiplication of Hansen's Bacillus in Complex Symbiosis *in vitro*.—Dr. R. Devignat 832

Rhamnose for Detection and Isolation of *Azotobacter vinelandii* Lipman.—Vagn Jensen 832

VIROLOGY

Mutation in Tobacco Mosaic Virus induced by a New Carcinogen, 4-Nitroquinoline N-Oxide.—Dr. Hideya Endo, Akiyoshi Wada, Kin-ichiro Miura, Zyun Hidaka and Chuji Hiruki 833

Hæmagglutinating Sub-units released from Newcastle Disease, Para-influenza 1 and Mumps Viruses by Treatment with Ether.—F. Sokol, D. Blaskovic and O. Krizanová-Laucíková 834

CYTOLOGY

The Stainable Mucin of Joint Tissues and Synovial Fluid.—Dr. B. F. Martin and N. E. Shaw . . . 835

Nucleic Acid Content of Haploid and Diploid Cells of *Protomyces inundatus*.—L. R. G. Valadon, Dr. J. G. Manners and A. Myers 836

GENETICS

Pulmonary Tumours, Group VII and Sex in the House-Mouse.—Dr. J. A. H. Tatchell 837

Existence of Multiple Sex Genotypes in the Hermaphrodite Polychaete Worm *Ophryotrocha puerilis siberti*.—Prof. G. Bacci and O. Bortesi 838

AGRICULTURE

Amines in Silage.—H. Neumark 839

MATHEMATICS

Relationship between the True and Mean Anomalies.—C. J. Brookes 839

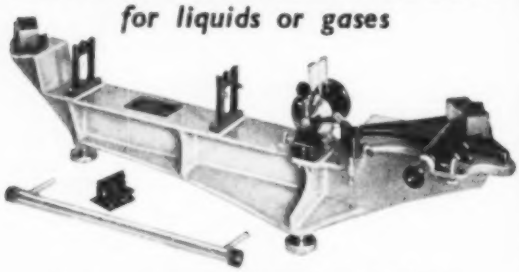
The Complete *n*-Point Graph.—H. P. Goodman . . 840

STATISTICS

A Basic Notion in the Theory of Cognitive Systems.—Dr. M. C. Goodall 840

PRECISION BS INSTRUMENTS

Jamin Refractometer
for liquids or gases



Average accuracy in measurement of refractive index is approximately 0·000001 for gases and 0·000002 for liquids.

The elimination of all spring adjustment to the mirrors results in great stability and freedom from vibration. Worm wheel gearing actuates the compensator. Tubes up to 50 cm. length can be used.

Bellingham & Stanley Ltd.
DEPT. N, 71 HORNSEY RISE, LONDON, N.19
PHONE: ARCHWAY 2270
Sole distributors in U.K. for Schott Monochromatic Interference Filters

GRIFFIN
Established in 1820

MODERN FURNACE TECHNOLOGY

H. ETHERINGTON, B.Sc., A.R.S.M.
G. ETHERINGTON, B.Sc., M.B.A., J.D.

For the Third Edition this standard treatise has been extensively revised and brought up to date by the distinguished American authors. In explaining the scientific principles underlying design construction and operation of every type of furnace the book passes in review the whole science of combustion, gas flow, and heat transfer. Typical calculations, with illustrative diagrams, are included and a series of entirely new nomograms appear. There are new sections on flames, automatic combustion control, heat balance diagrams, gas friction calculations, and refractories recently developed.

A most valuable work for all concerned with theory, design, and operation of metallurgical and process furnaces—including also gas-producer plant.

THIRD EDITION. 570 pages, 9 in. × 6 in. 85 figures, 6 plates, numerous tables. Special 'hard wear' binding. *Just published*—**120s. net**

DRURY LANE
LONDON

ADVERTISING RATES IN NATURE

	1 Insertion @ per in.	6 Insertions @ per in.	13 Insertions @ per in.	26 Insertions @ per in.	52 Insertions @ per in.
Whole page	£52 0 0	£48 0 0	£44 0 0	£40 0 0	£36 0 0
Half page	28 0 0	26 0 0	24 0 0	22 0 0	20 0 0
Quarter page	15 0 0	14 0 0	13 0 0	12 0 0	11 0 0
Eighth page	8 0 0	7 10 0	7 0 0	6 10 0	6 0 0
Sixteenth page	4 5 0	4 0 0	3 15 0	3 10 0	3 5 0

COLOUR: Orange £15 extra, Standard Blue or Green £20 extra, other colours by arrangement.

Guaranteed positions.

Front Cover	£15 per page extra
Back cover	£10 „ „ „
Inside Covers, First Right Hand Page, Facing Matter	£8 „ „ „ (and pro rata)
Other Stipulated Pages	£3 per page extra (and pro rata)

CLASSIFIED ADVERTISEMENTS

are charged at 18s. for the first two lines and 6s. per line after (lines containing words in capitals count as two lines). Average six words to a line. 1s. is charged for the re-direction of replies to advertisements with a box number. Semi-display £4 16s. per single column inch.

All advertisements are subject to space being available and to the approval of the Proprietors, who reserve the right to refuse publication.

ACADEMIC FREEDOM IN SOUTH AFRICA

WHATEVER view may be taken as to whether South Africa should continue to be a member of the Commonwealth while her Government pursues the policy of apartheid, the withdrawal of South Africa from the Commonwealth can only be regarded, as the Prime Minister said in the House of Commons on March 22, as a very sad event; "sad because of what seems to us a tragically misguided and perverse philosophy which lies at the root of apartheid; sad because of the many people in South Africa . . . who would like it at least tempered and made more elastic and more humane; sad because this event marks the end of an association of our countrymen for more than a hundred years with Colonies formed in Capetown, Natal and elsewhere; sad because it is the end of a fifty-year connexion which began with a decision then hailed as an outstanding example of magnanimity after victory; sad because it makes a breach in a community which has a great part to play in the world".

The issue of apartheid in connexion with academic freedom has, of course, been discussed several times in these columns (see *Nature*, June 6, 1959, p. 1551). It has already created difficulties with which some scientists have been particularly concerned. It has to some extent jeopardized the contribution which South Africa could make to the work of the Scientific Council for Africa South of the Sahara and of the Commission for Technical Co-operation in Africa South of the Sahara, and it has struck a serious blow at the South African universities. With the best will in the world, it is unlikely that those difficulties will diminish in a South Africa outside the Commonwealth. As Mr. Duncan Sandys, the Secretary of State for Commonwealth Relations, rightly said in the debate in the House of Commons, we must not let it be thought that it makes no difference whether one is in or out of the Commonwealth. This Mr. Sandys reaffirmed on April 24 in introducing the Republic of South Africa Temporary Provisions Bill. In his recent speeches, Dr. Verwoerd has been giving the impression that South Africa's withdrawal will make no difference; but while there will be a general wish to maintain close relations with South Africa and particularly to do anything that may be possible to help those South Africans who cherish their ties with Great Britain and are opposed to Dr. Verwoerd's policy and action, the position has been greatly changed by that withdrawal.

The effect of withdrawal on scientific research in South Africa and on South Africa's co-operation in scientific and technical matters was not discussed in either House of Parliament; but in the debate on South Africa and the Commonwealth in the House of Lords on March 23, Lord Beveridge referred briefly to the universities. Lord Hailsham, in opening the debate, had pointed out that, while it would be idle to pretend that the withdrawal from the Commonwealth would not affect relations between the two countries, time alone would show how far-reaching that change would be. For that reason the Government had decided to introduce a standstill measure, so that we might have time to think in an atmosphere of friendliness and toleration exactly what our course should be.

Lord Hailsham referred particularly to our obligations to our South African fellow citizens in High Commission Territories, and said that we must maintain relations with the South African Government which permit us to discharge them honourably. In this connexion, however, it must also be remembered that the educational policy of the South African Government has already made it more difficult for the needs of those territories to be met by our existing arrangements, especially in respect of higher education. Questions of status and citizenship will also, as Lord Hailsham noted, require discussion in an atmosphere of calm.

Lord Beveridge, who stressed the importance of considering the interests of people of British descent and British outlook in South Africa, referred to the implications of the South African Government's policy of introducing racial discrimination into the open universities of Cape Town, the Witwatersrand and Natal. He regarded it as vital to the future of peace between coloured people and white people that these universities should be made open and self-governing and free from racial discrimination. Under the Extension of University Education Act of 1959, these universities cannot continue to accept non-white students without the written consent of the Minister, and up to the present, even while the non-white university colleges are being developed, the Minister has refused all but 2 out of 153 applications from Bantus.

That Act is a serious infringement of university autonomy which in itself could have disastrous consequences for the universities as well as for science and learning generally in South Africa. These consequences could perhaps be exaggerated, for a university is inevitably influenced by the kind of community in which it is situated, and university autonomy cannot be maintained in a community which does not understand its nature or seek to preserve it, however firm the safeguards against interference by Government; though it should be remembered that there is a considerable volume of opposition to the South African Government's policy within South Africa. No less serious, however, is the extent to which the Act shatters the South African university tradition by subjecting the whole of a university staff to appointment by a Minister and to control in all their university activities by Ministerial regulations and by a statutory code of discipline which stifles the academic conscience.

The South African Government's proposals were opposed at the time by the universities with noteworthy dignity and cogency, and in their opposition they had the unequivocably expressed support of the universities of the world. The South African Government, however, was quite unmoved by this opposition, and with the withdrawal of South Africa from the Commonwealth it must become increasingly difficult to assist the South African universities to sustain their old and high traditions of learning and investigation, even if they are still able to participate unhindered in the meetings of the universities of the Commonwealth. Only time can show to what extent they will find it more difficult to recruit staff of high standing, for either teaching or research. It is at least unlikely that outstanding investigators will be ready to enter institutions where such Ministerial restrictions on freedom of investigation and utterance are current; if the full effect is only felt as existing members of the universities reach retiring age, the ultimate result will be no less disastrous.

Leaving out of the discussion the needs of the coloured peoples of South Africa, which the South African Government proposes to meet by measures described by Lord Beveridge as utterly unworthy of being termed university education, it is a matter of doubt whether the South African universities, under these conditions, will be able to supply the scientists and technologists which the country needs to-day. Obviously they will be unable to supply the numbers required, for the exclusion of coloured races means that they can offer no contribution to the immense numbers of trained Africans that are required to deal with the urgent problems of development in Africa to-day. Any contribution to the expansion visualized at the Commonwealth Education Conference is likewise barred, and it is more than doubtful whether they will long continue to supply the white scientists and technologists of the high quality required. A system which strikes at the root of the free intercourse and communication on which scientific and technical advance depends, and forces South African workers to go to Britain or America to meet Africans of university standard and ascertain their views, as Dr. H. J. Grenville-Wells pointed out at the conference on university apartheid in November 1957, carries the seeds of its own decay.

The problem, however, is essentially to find some means of inducing the advocates of apartheid to realize the implications of its application in the universities as regards scientific and technical work, or professional work generally, and of considering the possibility of relaxation to avoid those untoward consequences. The English-speaking universities have protested with dignity and determination against this closure of their open doors, and the University of the Witwatersrand, in particular, not content with affirming the principle that a university is a place where men and women, without regard to race or colour, are welcome to join in the acquisition and advancement of knowledge, has dedicated itself to the maintenance of this ideal and to the restoration of its autonomy. Its members are fully aware that a university can only make its proper contribution to national life when it is assured of freedom to teach, to investigate, to discuss and to criticize, and that when deprived of any one of these the quality of its intellectual life will decline, creative work be stifled, research discouraged or discontinued, and ultimately the quality of its teaching become that of the school class-room. Nor are they under any illusions that time is on their side: unless their autonomy is regained before the new Act has its full insidious effect, their university status will be lost, perhaps irretrievably.

Sir Eric Ashby, who in *The Guardian* last year described some of the protests made by the English-speaking universities, finds some hope in the liberalism to be found among some Afrikaans-speaking intellectuals, although the four Afrikaans-speaking universities, the policy of which has been to enrol white students only, in public and officially subscribe to the policy of apartheid. Prof. B. B. Keet, of the University of Stellenbosch, and Prof. P. V. Pistorius, of the University of Pretoria, have both incisively condemned the Government policy, and probably the book, *Our Responsibility*, by the Hon. H. A. Fagan, formerly Chief Justice of South Africa, is even more influential. While it is unlikely that criticism even from such quarters will have much influence on the present South African Government, at this juncture of South Africa's withdrawal from the Commonwealth it is well to remember that the policy of apartheid finds its critics in South Africa among people of Dutch as well as of British stock.

The Act which strikes at the very existence of the South African universities has another effect. So far from extending university education, its immediate effect is to put higher education out of the reach of hundreds of non-whites. It is true that it established three so-called university colleges for Bantus and one for other non-whites, but so far they are out of reach of thousands of the students for whom they are professedly intended, and, apart from the legitimate doubts expressed by Lord Beveridge as to their academic calibre, there is no evidence that the South African Government is sincere in these constructive proposals of the 1959 Act. To all intents and purposes, the Act has wrecked any immediate prospect of the coloured peoples of South Africa being trained to a level permitting them to make the contribution to the development of Africa which they could justly expect to make.

That aspect will undoubtedly deeply influence the attitude of members of the United Nations to the South African Government, and it may well come to affect in due course South Africa's membership of such bodies as the Scientific Council for Africa South of the Sahara, though it must be remembered that the members of that Council are not representatives of Governments or responsible individually to the country from which they are drawn. The Council is rather a body of independent scientists, the primary allegiance of which is to the advancement of science for the benefit of Africa. The Commission for Technical Co-operation in Africa South of the Sahara, on

the other hand, is an inter-Governmental organization, and it remains to be seen to what extent it will be possible for the Commission to continue to provide a forum for the discussion of technical matters of importance to the continent while the South African Government maintains its present views on racial questions.

Just what the universities in the Commonwealth can do to offset the weakening of the South African universities by the action of the Government of the country is not easy to say. It is, of course, important that the Commonwealth universities should not confuse the South African universities with the South African Government, and if they can only give moral support, that should be given without stint and at every possible opportunity. The stand which the English-speaking universities of South Africa are making for academic freedom is writing a noble page in the history of the universities of the world. It is important that the academic world as a whole should be fully aware of what is happening in South Africa: of the courage of those who, in spite of sanctions, maintain their disapproval of the new Act; of the ostracism of members of the staff of Afrikaans-speaking universities who defend academic freedom. The withdrawal of South Africa from the Commonwealth has not changed such things, nor has it diminished the claims on the whole academic and scientific world for the support of those who in South Africa are striving so valiantly to maintain the conditions on which scientific advance and academic life depend.

ANALYSIS OF AGRICULTURAL MATERIALS, FOODS AND DRUGS

Official Methods of Analysis of the Association of Official Agricultural Chemists

Edited by William Horwitz. Ninth edition. Pp. xx + 832. (Washington, D.C.: Association of Official Agricultural Chemists, 1960.) 18 dollars.

THE Association of Official Agricultural Chemists was founded at Philadelphia, U.S.A., in 1884 by a group of chemists interested in the analysis of fertilizers and their application to growing crops. The earlier work of the Association was concerned with devising methods of analysis for fertilizers and other agricultural materials the composition of which was the subject of State laws; results obtained by these methods were accepted for enforcement purposes. Later, as further legislation controlling food, drugs, insecticides and fungicides was introduced, the interests of the Association widened to include these items. Eventually, in 1920, the methods were published in book form under the title *Official and Tentative Methods of Analysis of the Association of Official Agricultural Chemists*, and, by that time, the range of contents had become extensive, covering beverages, foods and related substances, in addition to agricultural materials and drugs.

Methods are continually being tested by the Association in order to keep pace with new legislation, and the established methods are constantly reviewed in the light of developments in analytical technique. Any changes or additional methods are published first in the Association's journal, and are eventually incorporated into the book of methods, which is revised every five years for this purpose. The present, ninth, edition therefore represents the accumulated work of 76 years.

Except for the omission of the words "and Tentative", the title of the book has remained the same during these nine editions, and, to those readers who are not familiar with the work of the Association, it could be misleading, as it suggests that agricultural analyses form the main subject. The table of contents shows this is not so: of the 43 chapters, only seven are directly concerned with agriculture. Indeed, the chapter on soils which was included in previous editions has now been omitted because of the specialized nature of that subject. In effect, the operative word in the title is "Official", and it is to analysts who are concerned with the examination of foods, beverages (both alcoholic and non-alcoholic), drugs, fertilizers and feeding stuffs that this book must prove most useful. As a source of standard methods it holds a unique position, and it is widely quoted for this purpose.

The changes occurring in the new edition are extensive. Classical methods tend to remain unaltered, although a colorimetric method for phosphorus is now included in the chapter on fertilizers, and a useful addition to the Kjeldahl method for determination of nitrogen is a means of standardizing the digestion heaters.

The work of the Association, however, is naturally directed more to modern problems; the danger to public health of pesticide residues on foods, for example, has emphasized the need for methods of determining trace amounts of these newer organic materials. The ninth edition includes methods applicable to certain crops for the extraction and determination of many such pesticides, including aramite, BHC, captan, DDT, malathion, methoxychlor, parathion, piperonyl butoxide, sulphenone and thiram.

Also in connexion with the presence of trace amounts are the methods for determining drugs and antibiotics in feeding stuffs. This subject has been extended considerably and now occupies a separate chapter. The chapter covering drugs in general contains many new methods and numerous revisions.

In developing the newer methods, the technique of chromatography on columns is used extensively for the isolation of the desired compounds; the use of paper chromatography is also made official for the first time in this edition, for example, for detecting commercial glucose in honey, other plant materials in vanilla extract and for the differentiation of the BHC isomers.

The examination of foods for "extraneous materials" has been of interest to the Association for many years, and the chapter on this subject, although little different from that in the previous edition, is particularly valuable. Many changes have been made in the section entitled "Nutritional Adjuncts", which now includes methods for the determination of vitamin A in margarine and in mixed feeds, and for the fluorometric determination of vitamin B_1 in bread. The individual methods for the microbiological determination of the B-group vitamins have been replaced by a single

general method with appropriate modifications for particular vitamins. A method for the biological evaluation of protein quality is also included in this section.

The actual amount of material in this book is continually increasing, and in order, therefore, to keep the size within reasonable bounds the style of this new edition has been changed to a larger page divided into two columns. The new format is easier to read, and I welcome the change, especially as it means that further abbreviations of the text have thus been avoided. H. V. HART

CONTROLLED THERMONUCLEAR REACTIONS

Plasma Physics and Thermonuclear Research

Vol. 1. Edited by G. Longmire, James L. Tuck and W. B. Thompson. (Progress in Nuclear Energy, Series XI.) Pp. vii+612+xii. (London and New York: Pergamon Press, 1959.) 105*s*. net; 15 dollars.

Nuclear Fusion

Edited by Prof. William P. Allis (Second Geneva Series on the Peaceful Uses of Atomic Energy.) Pp. viii+488. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1960.) 12.50 dollars; 94*s*.

Controlled Thermonuclear Reactions

An Introduction to Theory and Experiment. By Samuel Glasstone and Ralph H. Lovberg. Prepared under the auspices of the Office of Technical Information, United States Atomic Energy Commission. Pp. xvi+523. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1960.) 5.60 dollars; 42*s*.

THE opening in September 1958 of the second International Conference on the Peaceful Uses of Atomic Energy will go down in scientific history as the day the dam burst. It was then that the veil of secrecy was removed from some six years of intensive study in the United States, the United Kingdom and the U.S.S.R. of what is now generally called nuclear fusion. The views and results of hundreds of scientific workers were suddenly thrown open for free discussion, and were supplemented by an exhibition of working experimental equipment on an unprecedented scale.

The first of these three books provides the edited proceedings of this part of the Second Geneva Conference. It is divided into surveys of progress in the chief countries working in this field, followed by reviews of the main experimental devices, the *Stellarator*, the magnetic mirror, the plane shock and the pinched discharge.

These are succeeded by a series of more general theoretical papers on plasma physics and finally by proposals from the U.S.S.R. and the United States for more esoteric methods of stabilizing hot plasma, such as the *Astron*.

Valuable though this collection is, the papers are not easy reading; hence the second book, by Prof. Allis, which is successful in providing most of the information in a more easily digested form, is welcome.

The third work, by Glasstone and Lovberg, carries the process of digestion still further, and is an excellent advanced introduction to the whole subject. It is a graduate text-book carefully thought out to meet the needs of experimentalists rather than of theoreticians, though theoreticians will find it a valuable guide through the thicket of experimental results and devices. Particularly good is the second chapter. Here are discussed the physical conditions which have to be met for thermonuclear reactions to occur at all, as well as those needed to achieve a net gain of power in any practical device.

It is now clear that the difficulties in the way of the attainment of economic power by fusion of the isotopes of hydrogen are formidable. The fuel (deuterium gas or a deuterium–tritium mixture) must be confined in a space isolated from material walls and maintained in the ionized state at an extremely high temperature (some tens or hundreds of millions of degrees) for recurrent periods each lasting about a second. In nearly all proposals this confinement involves the use of powerful magnetic fields and in the forms most worked with—the simple pinch and the *Stellarator*—they have so far been found to fail because the confined plasmas are basically unstable. Instabilities may take several forms; to discover means of curbing them calls for a much deeper understanding of their nature than exists at present, and of the way they build up from small perturbations to large disturbances and so cause the plasma to escape.

The authors deal in as clear a way as seems possible to-day with this matter, as well as with radiation losses from a very hot plasma, including 'cyclotron' radiation loss at high temperatures, a spectre raised by Russian workers two years ago and not yet fully laid.

In his foreword to the book, Dr. A. E. Ruark expresses the hope that it will command the respect and gratitude of a world-wide audience. He can be assured that it will.

These three works show that the achievement of economical controlled thermonuclear power presents an exceptional scientific and technical challenge, one so difficult that it may indeed never be possible to meet. It is far too early to be pessimistic about the outcome of this great enterprise, but it is now clear that success will not be easily attained nor will progress be so rapid as with power from nuclear fission. BASIL SCHONLAND

CARBOHYDRATE CHEMISTRY

The Carbohydrates

By S. F. Dyke. (The Chemistry of Natural Products, Vol. 5.) Pp. v + 232. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1960.) 36*s*.

THIS book is one of a series of monographs designed to supplement the general text-book of organic chemistry with more detailed descriptions of the main groups of natural products. It gives a balanced account of the various facets of carbohydrate chemistry, and the text is adequately supplied with references to reviews and original papers. The author assumes little or no previous knowledge of the subject, but the treatment is sometimes sketchy and some of the material is presented in the form of notes with little commentary. One feels that the student would have been better served

if the evidence for recent developments in the field had been treated more fully, and if greater emphasis had been given to the present growing points of the subject. In these respects this volume does not reach the high standard set by some earlier volumes in the series.

The first three chapters of the book deal with the basic chemistry of the monosaccharides, their general reactions, stereochemistry, and ring structures. In the two following chapters, derivatives of monosaccharides are discussed, both those used in synthesis and structural studies, and those of natural occurrence, including the branched-chain sugars and deoxy sugars. It is a pity that, apart from two rare sugars found in antibiotics, sugars containing more than six carbon atoms are not discussed, and that no mention is made of the aldoheptoses found as constituents of polysaccharides from micro-organisms, or of the naturally occurring heptuloses and heptitols, or of the sialic acids with nine carbon atoms. The next chapter provides examples of *O*-glycosides of plant origin, but no space is found for any discussion of the chemistry of *N*-glycosides, for example nucleotides. The chapter on oligosaccharides gives examples of both chemical synthesis of disaccharides and of the determination of structure of di- and tri-saccharides. There follows a brief survey of polysaccharide chemistry, including an account of general methods of structural determination and a description of some representative groups. Although the full potential of enzymes as tools for structural investigation of polysaccharides has yet to be realized, one feels that their use in the elucidation of the fine structure of starch and related polysaccharides deserves more specific mention. The book is concluded with a chapter on carbohydrate metabolism with sections on glycolysis, photosynthesis, and the bio-synthesis of monosaccharides and polysaccharides.

At present-day prices the book is reasonable value. There are comparatively few errors, and the general standard of production is good.

G. O. Aspinall

HUMAN NUTRITION

Recent Advances in Human Nutrition, with Special Reference to Clinical Medicine

By Prof. J. F. Brock. Pp. xii + 454. (London: J. and A. Churchill, Ltd. 1961.) 50*s*. net.

PROF. BROCK has contributed considerably to our knowledge of human nutrition by a large amount of important research. Reluctantly, one must conclude that he has not contributed anything like so impressive a book.

To begin with, it is impossible to decide the sort of person for whom it was written. Certainly not for the average clinician, for he would have no idea of what is meant by "*cis-trans isomerism*". The nutritionist, on the other hand, would not accept that "there is no specific sign of riboflavin deficiency in the human". Moreover, the nutritionist would have to be very magnanimous to forgive the misspelling of one of the world's outstanding nutritionists as "Bam".

The first eighteen chapters of the book are written by Prof. Brock himself. The remainder is written by a number of other nutritionists, and, as is so common with multiple authorship, the result is uneven. Indeed, it is difficult to understand why some parts were included at all, since they have little or no bearing on nutrition. An interesting feature is that several chapters describe the nutritional work in particular areas; much of this information will be new even to many nutritionists.

It is understandable that Prof. Brock and his colleague Dr. Bronte-Stewart, who have done a great deal of original and important work on the subject, should stress the possible role of dietary fat in the causation of coronary disease. But in a book of this sort one would have liked to see rather more mention of the contradictory evidence in the alleged connexion between the two. Many would not agree, for example, that "only the dietary fat intake remains consistently in parallel with the mortality experience of this disease".

Again, one is disappointed to find that the myth is still perpetuated that the cause of obesity "remains a mystery". It is just not true that "there is still a fortunate majority who can dispose of excess calories with impunity and an unfortunate minority who have to count every calorie".

There are very few books dealing generally with the subject of nutrition, so that this book, by Prof. J. F. Brock, was eagerly opened and read by me. It is disappointing to have to report that the book does nothing to enhance the reputation of a most distinguished clinical nutritionist.

J. Yudkin

GRASSLAND PHILOSOPHY

The Grass Crop

Its Development, Use, and Maintenance. By Dr. William Davies. Second, revised edition. Pp. xv + 363 + 16 plates. (London: E. and F. N. Spon, Ltd., 1960. 45*s*.

THE second edition of William Davies's *The Grass Crop*, which has been brought up to date and somewhat enlarged, is again a welcome addition to the literature of the subject. This is not a text-book in the generally accepted sense nor yet a purely practical guide for farmers, for it is something much more profound and wider in its scope. It is, in fact, a clear exposition of grassland philosophy, and threaded throughout its pages is the philosophy of one who has studied grassland in all its facets and in many parts of the world. This is well illustrated by one sentence: "The world at large must recognize that the soil is its one heritage which it must pass on unspoilt and untrammelled to the generations to come".

How true this is and yet how often forgotten in the maelstrom of technical agricultural development to-day. Throughout the book, however, the author is at pains to emphasize the fertility-building properties of the ley as well as its contribution to reclamation and to solving the livestock feeding problems for milk and meat production which face us to-day. Two new chapters, "Farming Systems" and "Extending the Grazing Season", pin-point the remarkable changes that have occurred in our farming of recent years and outline something of the vast potential which the grass crop still has to offer.

A cautionary word, too, is uttered on the too slavish adoption—a modern trend—of statistical analysis of new techniques before they are advised for in-

corporation into farm practice. Each farmer should interpret experimental results for himself and try to relate them to his own specific conditions. He should try new methods which, in the light of his experience, offer advantages. The trial may fail, but it is far better to fail on the chance of succeeding than not to try out a new technique simply because in trial plots the results did not attain the desired level of significance to suit the statisticians.

Future prospects are very ably summarized in a final chapter when problems facing both research workers and farmers are clearly stated. The problems cited do not simply concern grass as a crop, but also the animals which consume the grass. Animal nutrition is as important as crop nutrition, and only of recent years has research indicated that there are fundamental differences in herbage plants which dictate the reactions of animals to them in the digestibility and production secured from them when eaten by ruminants. Parasitism raises a multitude of fresh problems which indicates the need for team work between physiologists, veterinarians and agronomists. Then, too, the underground parts of the grass plant are frequently as important, if not more so, than the aerial ones.

Since the first edition of this book appeared in 1952, our knowledge of the grass crop has greatly increased and the full appreciation of its vital role in British agriculture is now more widely acknowledged. The author incorporates throughout the text recent results from experiments at the Grassland Research Institute for Great Britain as well as from elsewhere.

All students of agriculture at all levels should make a point of not only reading this book carefully, but also of studying it seriously. An excellent bibliography and a serviceable index add greatly to its value for students. It has in my view, however, a wider value, and biologists, geographers, geologists and indeed all interested in the countryside will find profit and fascination in its pages.

Ian Moore

CRYSTAL GAZING

Computing Methods and the Phase Problem in X-ray Crystal Analysis

Report of a Conference held at Glasgow, August, 1960. Edited by Ray Pepinsky, J. M. Robertson, and J. C. Speakman. (International Tracts in Computer Science and Technology and their Application, Vol. 4). Pp. viii+326. (London and New York: Pergamon Press, 1961.) 63*s*. net.

Crystal-structure Analysis

By Prof. Martin J. Buerger. Pp. xvii+668. (New York: John Wiley and Sons, Inc.; London: John Wiley and Sons, Ltd., 1950.) 18.50 dollars; 148*s*.

ABOUT a decade ago there was held at Pennsylvania State College a conference on "Computing Methods and the Phase Problem in X-ray Crystal Analysis". The main purpose of this meeting was to exhibit the new X-*RAC* computer designed by Ray Pepinsky, and the volume which described the conference and the machine is one of the important landmarks in the literature of the subject.

Of the machine itself little need be said except that it forms the most powerful tool for Fourier synthesis which has so far been produced. The other papers in the earlier volume were chiefly concerned with the central problem of X-ray analysis, the determination of phase.

In the new book under review, we see how the hopes and aspirations of the workers have developed. The X-*RAC* is still the most powerful machine for its special purpose, but, as Pepinsky points out, it is "an anomaly among computers", an analogue machine which is more economical and capable of greater accuracy for its special purposes than any digital machine yet on the market. Nevertheless, the machine will become of less importance in the future because of the development of new techniques and of the essentially versatile nature of digital machines.

The main portion of the book is, however, concerned with two aspects of modern structure analysis: digital computation and phase determination. Of the former it may be said that all the principal machines and programmes are described. The papers vary from the mere catalogue of programmes for an *IBM* '650', provided by Jeffrey and Shiono, to the extensive description of *Pegasus* and its programmes given by Cruikshank. To say that these papers were dull would be unfair, but they are unlikely to be of great interest to anyone who does not have access to one of the machines described. An exception should perhaps be made in favour of Robertson's paper, which describes a charming little machine having the code-name *Rufus*, an indication that in these days of high-speed electronics there is still place for mechanical ingenuity.

The papers which deal with phase determination and theoretical crystallography are revealing. They range from the extremely useful analysis of least-squares techniques by Sparks, to the disappointingly short paper on the later history of direct methods of phase determination by Hauptman. Experimental methods of phase determination also receive attention and the phase part of the book may be summed up by the statement that, with complex structures at least, if no experimental method of phase determination is available the theoretical methods are unlikely to be of much help.

The book is well produced, and authors, editors and publishers alike must be congratulated on producing it so soon after the conference. It will be an essential book for all serious crystallographers.

Buerger's book, while dealing with many of the topics covered by the specialists in the previous work, is a systematic study of the whole process of crystal structure analysis. It starts with a description of the fundamental processing of X-ray diffraction, explains the experimental techniques which are used to obtain X-ray data, and then derives the various expressions which are needed to reduce these data to a form suitable for Fourier analysis.

The latter part of the book is a compendium of Fourier methods, from practical procedures of computation to theoretical techniques of phase determination. Although the book contains nearly 700 pages the whole subject of vector space is barely mentioned—it is the subject of an earlier book by Buerger—and one gets the impression of increasing compression of treatment towards the end. This terseness is, however, relieved by the excellent lists of references which end each chapter, and, were it not for the extremely high price, every student of crystallography would find the book an essential part of his library.

A. D. Booth

Tin and Its Alloys

Edited by Dr. Ernest S. Hedges, with the collaboration of Prof. J. W. Cuthbertson, Prof. E. C. Ellwood, Dr. W. E. Hoare and W. R. Lewis. Pp. viii+424. (London: Edward Arnold (Publishers), Ltd., 1960.) 126*s.* net.

THIS book of more than four hundred pages is more in the nature of an encyclopaedia than a text-book, and no significant aspect of tin and its uses is overlooked. Prepared by experts in the different aspects of the subject, all of whom are, or have been, connected with the Tin Research Institute, the treatment is authoritative. Despite the wide scope of the ground covered, there is nothing superficial in the discussions, and the 187 figures are well reproduced and pertinent.

After an introduction by Dr. E. S. Hedges, tin in its cast and wrought forms is dealt with, and it will come as a surprise to many to learn that several tons of the metal are to be seen in the enormous pipes in the organ at the Albert Hall in London. Two chapters are concerned with the physical metallurgy and chemical behaviour of tin and its alloys. The approach, however, is really to the user of the metal, and the treatment of the scientific aspects is subordinate to the more directly practical. It is, however, adequate both for the purposes of the manufacturer and for the engineer, chemical or otherwise, who uses the product. Where so much is good, it is almost invidious to single out Prof. Cuthbertson's account of the metallography of the bronzes for special mention.

The electrodeposition of tin and its alloys, hot-tinning, tin-plate, tin in bearing alloys, die-casting alloys, solders and bronzes are all treated at sufficient length to be really informative. The extent of the treatment is vast, and readers interested in the tomb of the Empress Maria Theresa, in the tinning of cast iron or in Babbitt's original patent of 1839 will all find what they seek.

Within the obvious limitations of the space available, it is difficult to see how this publication could have been bettered. F. C. THOMPSON

The Moon

Our Nearest Celestial Neighbour. By Prof. Zdeněk Kopal. Pp. vii+131+15 plates. (London: Chapman and Hall, Ltd., 1960.) 25*s.* net.

FOR many years the Moon was neglected by all except a few enthusiastic amateur observers. The recent developments in space research have led to a welcome change of attitude, and professional astronomers also have begun to pay attention to lunar studies. The latest book on the subject, by Prof. Z. Kopal of the University of Manchester, is written at an elementary level, and may be followed throughout by the layman; its greatest appeal will probably be to younger readers. It is attractively produced, and the photographs, many of which have been taken at the Pic du Midi Observatory, are excellent.

Beginning with fundamental facts, the author goes on to describe what he calls "the Strange World of the Moon", and considers the various theories of crater formation. On this controversial subject he is wisely cautious, and believes that both vulcanism and meteoric impact may have played a part in the moulding of the surface. The actual nature of the surface is further discussed in the next two chapters, after which a section is devoted to the observation of an outbreak inside the crater Alphonsus, reported in 1958 by the Russian astronomer N. A. Kozyrev. The final chapter is entitled "Destination Moon", and is frankly speculative, though the author carefully refrains from any flights of fancy.

A few minor criticisms may be made. In particular, some of the important studies of recent years are not mentioned; a notable omission is any reference to G. Fielder's investigations with regard to the lunar grid system. There are also one or two over-simplifications, and a number of misprints, such as 'air' instead of 'aid' on p. 19. The general impression is, however, of a very pleasant and readable little book. PATRICK MOORE

Practical Organic Chemistry

By Dr. Frederick George Mann and Dr. Bernard Charles Saunders. Fourth edition. Pp. xix+585. (London: Longmans, Green and Co., Ltd., 1960.) 25*s.* net.

FOUR editions within twenty five years testify to the success of this book in a highly competitive market. They also mark the authors' concessions to the claims of evolving techniques. In this latest edition increased emphasis is given to semi-micro methods, both of preparing and characterizing organic compounds; there is a section—all too brief—on chromatography, including the use of ion-exchange resins; the scope of qualitative analysis is enlarged over that of previous editions; and the variety of standard syntheses is increased by new examples. Spectroscopy is not included, and perhaps this is wise although, even in organic teaching laboratories, automatically recorded spectra are now increasingly invoked. Certainly, in spite of judicious pruning, the new edition is larger by more than a hundred pages and further increase must bring into question the advisibility of combining within a single volume both elementary and more advanced techniques. Meanwhile, "Mann and Saunders" maintains the style and character which have given it wide acceptance. J. D. LOUDON

Qualitative Organic Analysis

By B. Haynes. Pp. 239. (London: Cleaver-Hume Press, Ltd., 1961.) 17*s.* 6*d.*

THIS book is designed for students in the range from National Certificate to university-level. It is self-contained in that detailed instructions for each step towards identifying a simple substance or mixture are combined with reference tables of melting points and boiling points for a generous selection of compounds and their useful derivatives. It gives the author's approach to teaching the subject and bears his emphases and preferences. Stress is placed on preliminary tests, chemical formulæ and equations are deliberately omitted, and supplementation by lectures is implied. A good standard of lucid description is maintained throughout, but the order in which classification tests are arranged will not appeal to all tastes, and more generally, one feels that the student may have difficulty in penetrating the mass of detail to the principles underlying the analysis. However, the book is rich in sound, useful information and fully merits consideration by teachers of the subject.

J. D. LOUDON

STRONTIUM-90 IN FALL-OUT AND IN MAN IN AUSTRALIA, JANUARY 1959—JUNE 1960

By DR. F. J. BRYANT
Atomic Energy Research Establishment, Harwell
L. J. DWYER, D. J. STEVENS, PROF. E. W. TITTERTON, C.M.G.
Australian Atomic Weapons Tests Safety Committee
AND
and J. R. MORONEY
Department of Supply, Melbourne

EARLY in 1956 a network of stations established by the Atomic Weapons Tests Safety Committee commenced to monitor radioactivity in fall-out over Australia from weapon tests at the Monte Bello Islands and at Maralinga, as well as from those held overseas[1–7]. The number of stations operative, as well as the type of sampler employed in this network, has varied from time to time. Many more stations were used during periods of weapon tests in Australia, and the sensitivity of monitoring techniques has been improved as fall-out levels decreased. Early in 1957 the monitoring programme as a whole was extended to include the determination of strontium-90 in materials representative of the Australian environment, and this has become a major feature of the programme. The results from this strontium-90 survey to the end of 1958 have already been reported[8], and since that time the number of samples collected has been increased considerably. Thus, 744 specimens of total precipitation, soil, powdered milk, cabbages, wheat grain, and sheep and human bones were collected during 1959, and 1,230 during 1960. In order to avoid unnecessary analyses, specimens of the same type were sometimes combined together to provide a single representative sample, and as a result a total of 480 analyses are involved. The analytical effort is being provided by the following laboratories:

(1) Human bone; by the Woolwich Outstation of the Atomic Energy Research Establishment, Harwell (under the direction of one of us—F. J. B.), and the Lamont Group at Columbia University; (2) precipitation samples: by the Health and Safety Laboratory of the U.S. Atomic Energy Commission, as part of a world-wide 'high wall pot' programme; (3) wheat grain: by the U.K. Agricultural Research Council Radiobiological Laboratory; (4) all other material: by the Woolwich Outstation of the Atomic Energy Research Establishment, Harwell.

Although analysis of all samples for the period is not yet complete, extensive data for human bone, from Woolwich, and for precipitation, from the Health and Safety Laboratory, are to hand for the 18-month period January 1959–June 1960. Because of their importance and interest, they are reported in this article. Later this year the bone data from Lamont will be published with all other data.

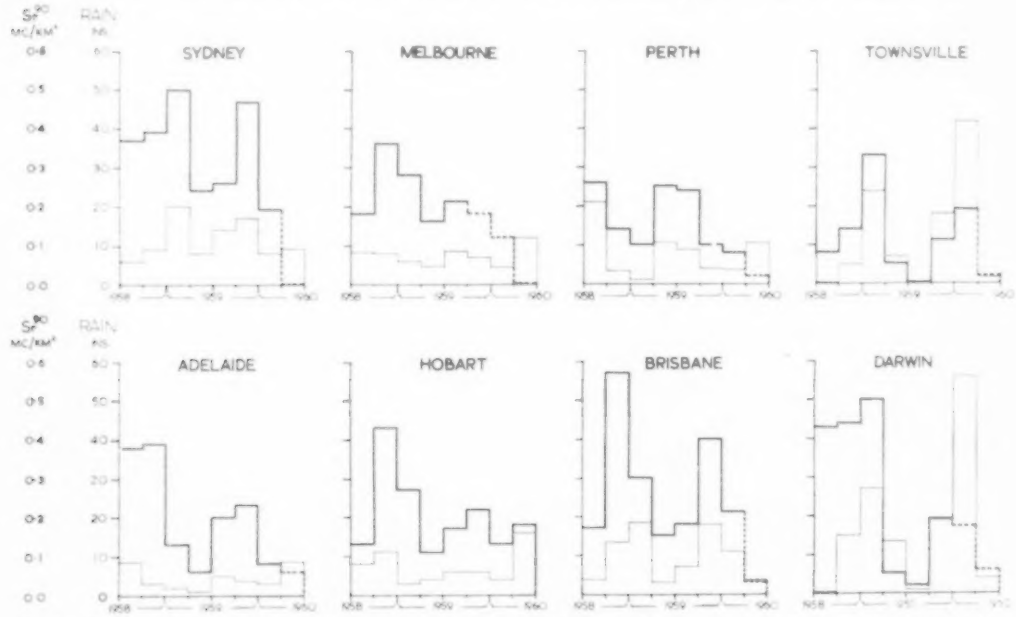


Fig. 1. Strontium-90 in Australian precipitation samples, July 1958–June 1960, combined in 3-monthly intervals. The histograms of the strontium-90 data are depicted by the heavier line; the broken line indicates where the data were incomplete at the time of plotting. Rainfall totals for the corresponding periods are shown as the lighter line

Table 1. (*a*) STRONTIUM-90 IN AUSTRALIAN HUMAN BONE, 0–59 MONTHS, JANUARY 1959–JUNE 1960

The age of each specimen contributing to a sample is given; where there is more than one specimen of a particular age, the number is shown in brackets. An asterisk indicates that no specimens were available in the age-group, although in some cases†, because the available specimen mass was insufficient for analysis, the specimens were combined with adjacent age-groups

Origin	January–June 1959			July–December 1959			January–June 1960		
	Age (months)	No. of specimens	^{90}Sr $\mu\mu$c./gm. Ca	Age (months)	No. of specimens	^{90}Sr $\mu\mu$c./gm. Ca	Age (months)	No. of specimens	^{90}Sr $\mu\mu$c./gm. Ca
0–1 month									
Perth	*	*	*	*	*	*	*	*	*
Adelaide	0 (2)	2	0·65	0 (13)	13	0·50	0 (14)	14	0·45
Melbourne	0 (7)	7	0·8	0 (6)	6	0·6	0 (6)	6	0·65
Sydney	0 (4)	4	0·55	0 (3)	3	0·6	0 (10)	10	0·45
Brisbane	*	*	*	*	*	*	*	*	*
1–23 months									
Perth	0†, 1, 13, 24†	4	0·85	0†, 1 (2), 3, 4 (2), 5, 7 (2), 8, 16, 20	12	0·95	0†, 7 (3), 45†	5	1·1
Adelaide	3, 6, 14	3	1·2	0†, 1 (10), 2 (5), 3 (2), 5 (4), 6, 7, 8 (2), 12, 14, 24†	29	1·15	1 (7), 2 (2), 5, 6 (2), 8, 12, 14, 18	16	0·9
Melbourne	1, 2, 3, 7, 8, 10 (2), 11, 18	9	1·35	1 (4), 2 (4), 3 (2), 8 (2), 20	13	1·0	1 (3), 2 (2), 3 (2), 4, 5 (2), 6, 8	12	0·9
Sydney	1 (4), 2, 4 (2), 7, 9, 14, 18	11	1·25	3, 4, 6, 8 (2), 9, 10 (2), 11, 15, 22	11	0·7	1 (8), 2 (3), 3 (4), 4, 9, 10 (2), 15, 17, 19	22	0·9
Brisbane	0†, 1, 3, 4, 18	5	0·65	2, 4, 15	3	0·9	5, 9, 18, 24†, 48†	5	0·95
24–59 months									
Perth	*	*	*	24, 30, 36	3	1·4	*	*	*
Adelaide	36, 48	2	0·65	24, 31, 34, 48, 56	5	0·95	24, 27, 30, 42, 48	5	1·3
Melbourne	*	*	*	24, 34	2	1·9	24, 25 (2), 33, 48, 55	6	0·9
Sydney	24 (2), 40	3	0·85	30, 36, 42, 48	4	1·35	24 (2), 30, 36, 46	5	0·95
Brisbane	24, 36 (2), 44, 48	5	0·65	*	*	*	*	*	*

Table 1 (*b*). STRONTIUM-90 IN AUSTRALIAN HUMAN BONE, 5–19 YEARS, JANUARY 1959–JUNE 1960

The bracketed figures give the number of specimens from which the samples were derived for analysis

Origin	Jan.–June 1959	July–Dec. 1959	Jan.–June 1960
	^{90}Sr $\mu\mu$c./gm. Ca	^{90}Sr $\mu\mu$c./gm. Ca	^{90}Sr $\mu\mu$c./gm. Ca
Perth	0·5 (2)	0·55 (7)	0·45 (3)
Adelaide	0·60 (9)	0·50 (12)	0·65 (7)
Melbourne	0·50 (10)	0·60 (5)	0·75 (4)
Sydney	0·50 (9)	0·55 (13)	0·75 (17)
Brisbane	0·6 (5)	0·50 (9)	0·50 (14)

Table 1 (*c*). STRONTIUM-90 IN AUSTRALIAN HUMAN BONE, MORE THAN 20 YEARS, JANUARY 1959–JUNE 1960

Comparisons between cities can only be made where the bone types are identical; normalization to a skeletal mean has not been attempted. For convenience, the specimens collected in each capital city during 1959 were analysed as one group. The bracketed figures give the number of specimens from which the samples were derived for analysis

Origin	January–December 1959		January–June 1960	
	^{90}Sr $\mu\mu$c./gm. Ca	Bone	^{90}Sr $\mu\mu$c./gm. Ca	Bone
Perth	0·35 (24)	vertebræ	0·47 (26)	vertebræ
Adelaide	0·30 (18)	ribs	0·48 (24)	ribs
Melbourne	0·14 (72)	crania	0·12 (37)	crania
Sydney	0·35 (148)	vertebræ	0·43 (52)	vertebræ
Brisbane	0·30 (75)	vertebræ	0·40 (55)	vertebræ

Sampling Methods and Results

(*a*) *Human bone tissue.* Between January 1, 1959, and June 30, 1960, 890 specimens of human bone tissue were collected through the agency of pathologists in the five capital cities—Perth, Adelaide, Melbourne, Sydney and Brisbane. Each of these specimens was ashed at 800° C. and then weighed. The ashed specimens were divided into three groups corresponding to the periods: January 1–June 30, July 1–December 31, 1959, and January 1–June 30, 1960. For each of the five capital cities specimens collected during these periods were divided into five age-groups: less than one month, 1–23 months, 24–59 months, 5 years–19 years and 20 years and older. In a few cases there were gaps due to specimens for the relevant period and age-groups being unavailable. Within each age-group an equal mass of ash was taken from individual specimens, and these equal masses were combined to form the sample for analysis. The resulting 59 samples were analysed by the Woolwich group.

The reported, near-uniform distribution of strontium-90 through skeletons of age up to 20 years[8,10] allowed samples representative of the four age-groups to be prepared by mixing different bone types from the appropriate collection periods. However, in view of the known non-uniformity of strontium-90 concentration in the adult skeleton, the survey of adult tissue was restricted to a single bone type for each capital city.

The results are presented in Tables 1*a*, *b* and *c*; the age of each infant specimen is included in Table 1*a*.

(*b*) *Total precipitation.* Stainless-steel high-walled pots, 12 in. diameter and 12 in. high, were continued in operation at the eight stations: Perth, Adelaide, Melbourne, Hobart, Sydney, Brisbane, Townsville and Darwin. The monthly collections from these pots were analysed at the Health and Safety Laboratory[11]. The analytical results from July 1958 until June 1960 have been accumulated in 3-monthly intervals and plotted as histograms in Fig. 1. Rainfall data have been arrayed in a corresponding manner.

Discussion

Fig. 1 indicates an overall increase in strontium-90 fall-out over Australia in late 1958 and early 1959. During 1959 the level decreased markedly before increasing somewhat in most localities towards the end of the year. The relatively short period covered by the data in Fig. 1 precludes a constructive analysis of any relationship between fall-out and precipitation in Australia. Further seasonal variations in deposi-

Table 2. Strontium-90 Deposition in Australia, United Kingdom and United States

Location	Deposition in mc. ^{90}Sr/km.^{2}			
	July–Dec. 1958	Jan.–June 1959	July–Dec. 1959*	Jan.–June 1960*
Australia				
Adelaide	0·77	0·19	0·43	0·19
Brisbane	0·74	0·45	0·58	0·33
Darwin	0·87	0·55	0·21	0·23 (5)
Hobart	0·56	0·38	0·39	0·31
Melbourne	0·54	0·44	0·39 (5)	0·16 (4)
Perth	0·40	0·35	0·34	0·19
Sydney	0·76	0·74	0·73	0·34
Townsville	0·22	0·38	0·11	0·22
United Kingdom				
Milford Haven	2·94	4·12	1·61	0·94
United States				
Los Angeles	0·25	2·38	0·27	0·64
New York	2·56	7·86	0·96	1·22

* Not all analyses of monthly samples from these periods are complete. When the set is incomplete, the bracketed figure gives the number of months represented; a crude approximation to the level for the six-month period can be made by scaling appropriately.

tion of strontium-90 are to be expected in the future, and an analysis of these may be profitable at a later stage if there is no further large-scale injection of strontium-90 into the atmosphere. For purposes of comparison, Table 2 presents the data combined in 6-monthly periods, together with results from measurements in the United Kingdom[12,13] and the United States[11]. The British station is that at Milford Haven, where measurements have been made since 1954, and for which the most detailed data exist. The American station at Los Angeles is selected as being representative of the west coast of the United States, where fall-out levels are, in general, low; the region of higher fall-out, on the east coast, is represented by New York.

The deposition of strontium-90 in Australia in the period July 1958–June 1959 ranged from 0·6 to 1·5 mc./km.^{2}, with a mean value for the eight stations of 1·0 mc./km.^{2}. The 1·0 mc./km.^{2} is one-third of the deposition at Los Angeles, one-tenth of that at New York and one-seventh of that at Milford Haven, in the corresponding period. The results for Australia do not show the marked rise in deposition of strontium-90 evident in the northern hemisphere during the period January–June 1959, which was mainly due to weapon tests during October–November, 1958.

The strontium-90 content of bone tissue is known to vary between individuals of a single age-group and from one group to another. Some difference between the results for the capital cities in individual age-groups is therefore to be expected, particularly when the number of specimens in the sample is small. The observed differences are not systematic throughout all age-groups, and the results in each age-group have been combined to give weighted mean values for Australia. These are shown in Table 3, which also includes the results of measurements on bone tissue in the United Kingdom[14–18] for comparison.

For all age-groups the mean level of strontium-90 in Australian human bone increased during 1958–59; but for younger tissue this rise was not carried into 1960. For the 0–1 month and 1–23 month age-groups, the increase was about two-fold; but it was followed by a downward trend into 1960. The level in the 24–59 month age-group rose later in 1959. The 5–19-year and over 20-year age-groups showed a slow rise over this period, which is to be expected with the turnover of pre-existing bone and, in the case of children and adolescents, the accretion of new bone tissue.

A similar, approximately two-fold rise in the strontium-90 level of infant human bone tissue also occurred in the United Kingdom in the period 1958–59. In general the levels of strontium-90 in Australian human bone are one-half to one-third of those in the United Kingdom[14–18]. Data for the United States, published by the Lamont Group[19], indicate levels 2–3 times higher than those in Australia.

Conclusions

(1) Mean levels of deposition of strontium-90 in Australia were about one-fourth of those in the United Kingdom and eastern United States during the period July–December, in both 1958 and 1959. The marked increase in fall-out rate in the northern hemisphere during the first half of 1959 was not experienced in Australia. It is probable that the mean annual deposition of 1·0 mc./km.^{2} recorded in Australia for the 12-month period July 1958–June 1959, will not be exceeded.

(2) The measurements on Australian infant bone tissue indicate that the level of strontium-90 in newly formed bone passed through a maximum during the period January–June 1959, and showed a downward trend to mid-1960. As expected, the levels in child, adolescent and adult bone tissue continued to increase gradually. At all ages the levels in Australian human bone tissue are one-half to one-third those in the United Kingdom and the United States.

(3) The Medical Research Council in Britain recently[20] accepted a recommendation of the International Commission on Radiological Protection that the maximum permissible level of strontium-90 in bone, averaged over the whole population, should be 67 $\mu\mu$c./gm. calcium, and for any individual in the population, 200 $\mu\mu$c./gm. calcium. At the same time, the Council revised its previous cautionary level at which a re-assessment of the situation would be required, from 10 to 33 $\mu\mu$c. strontium-90/gm. calcium. It will be seen that the levels found for

Table 3. Strontium-90 in Australian and British Human Bone, January 1958–June 1960 ($\mu\mu$c. ^{90}Sr/gm. Calcium)
The bracketed figures give the number of specimens on which the result is based

Period	0–1 month		1–23 months		24–59 months		5–19 years		More than 20 years	
	Australia	U.K.	Australia	U.K.	Australia	U.K.	Australia	U.K.	Australia*	U.K.†
Jan.–June 1958	0·39 (8)	0·55 (92)	0·66 (27)	1·74 (23)	0·68 (10)	1·28 (11)	0·34 (20)	0·72 (20)	0·24 (43)	0·45 (7)
July–Dec. 1958	0·2 (2)	0·85 (34)	0·51 (4)	1·74 (5)	0·5 (1)	1·23 (3)	0·32 (5)	0·87 (5)	0·20 (6)	0·40 (4)
Jan.–June 1959	0·70 (13)	1·16 (49)	1·13 (32)	2·74 (35)	0·71 (10)	2·14 (9)	0·54 (35)	0·93 (15)	0·33 (247)	0·58 (33)
July–Dec. 1959	0·54 (22)	1·14 (152)	1·00 (68)	3·27 (77)	1·30 (14)	1·90 (13)	0·53 (46)	0·89 (16)		
Jan.–June 1960	0·49 (30)		0·92 (60)		1·04 (16)		0·64 (45)		0·43 (133)	

* Vertebræ only.
† United Kingdom results for adult femora have been converted to the equivalent vertebral value using a factor vertebra/femur 1·5.

strontium-90 in Australian human bone are very much lower than the cautionary level.

[1] Butement, W. A. S., Dwyer, L. J., Eddy, C. E., Martin, L. H., and Titterton, E. W., *Austral. J. Sci.*, **20**, 125 (1957).

[2] Butement, W. A. S., Dwyer, L. J., Martin, L. H., Stevens, D. J., and Titterton, E. W., *Austral J. Sci.*, **21**, 63 (1958).

[3] Dwyer, L. J., Martin, J. H., Stevens, D. J., and Titterton, E. W., *Austral. J. Sci.*, **22**, 97 (1959).

[4] Dwyer, L. J., Keam, D. W., Stevens, D. J., and Titterton, E. W., *Austral. J. Sci.*, **20**, 39 (1957).

[5] Keam, D. W., Dwyer, L. J., Martin, J. H., Stevens, D. J., and Titterton, E. W., *Austral. J. Sci.*, **21**, 8 (1958).

[6] Keam, D. W., Dwyer, L. J., Martin, J. H., and Titterton, E. W., *Austral. J. Sci.*, **22**, 51 (1959).

[7] Blake, J. R., Dwyer, L. J., Martin, J. H., and Titterton, E. W., *Austral. J. Sci.*, **23**, 69 (1960).

[8] Bryant, F. J., Dwyer, L. J., Martin, J. H., and Titterton, E. W., *Nature*, **184**, 755 (1959).

[9] Schulert, A. R., Hodges, E. J., Lenhoff, E. S., and Kulp, J. L., *Health Phys.*, **2**, 62 (1959).

[10] Information from J. F. Loutit and one of the authors (F. J. B.), as yet unpublished.

[11] *U.S. Atom. Energy Comm. Health and Safety Lab. Reps.*, 55, 65, 69, 77, 84, 88, 95, 105.

[12] Crooks, R. N., Owers, M. J., Osmond, R. G., and Fisher, E. M. R., *U.K. Atom. Energy Res. Estab. Rep., R* 3094 (1959).

[13] Crooks, R. N., Osmond, R. G., Owers, M. J., Fisher, E. M. R., and Evett, T. W., *U.K. Atom. Energy Res. Estab. Rep., R* 3349 (1960).

[14] Bryant, F. J., Henderson, E. H., Spicer, G. S., Webb, M. S. W., and Webber, T. J., *U.K. Atom. Energy Res. Estab. Rep., C/R* 2816 (1959).

[15] Bryant, F. J., Cotterill, J. C., Henderson, E. H., Spicer, G. S., and Webber, T. J., *U.K. Atom. Energy Res. Estab. Rep., R* 2988 (1959).

[16] Arden, J. W., Bryant, F. J., Henderson, E. H., Lloyd, G. D., and Morton, A. G., *U.K. Atom. Energy Res. Estab. Rep., R* 3246 (1960).

[17] Bailey, N. T. J., Bryant, F. J., and Loutit, J. F., *U.K. Atom. Energy Res. Estab. Rep., R* 3299 (1960).

[18] *U.K. Med. Res. Coun. Monitoring Rep. Ser.*, No. 1 (1960).

[19] Kulp, J. L., Schulert, A. R., and Hodges, E. J., *Science*, **132**, 448 (1960).

[20] *The Hazards to Man of Nuclear and Allied Radiations* (U.K. Med. Res. Coun. 1960).

L. EULER, THE PRINCIPLE OF RELATIVITY AND THE FUNDAMENTALS OF CLASSICAL MECHANICS*

By D. SPEISER

Institute for Advanced Study, Princeton

SINCE they received their definite form through Newton, the significance of the fundamentals of classical mechanics has always remained a controversial subject, at least up to 1905. Where Newton had spoken of absolute space and time, and referred to experiments, some of his successors pretended that they did not need such hypotheses, or even went so far as to reduce his famous second axiom to a mere definition. Thus the boundary between mathematics and physics as an experimental science was strongly displaced at the expense of the latter, from which the so-called pure mechanics was separated.

Others, on the contrary, insisted on the basically experimental character of this axiom. There have been many attempts to display the long series of arguments from all sides of this very involved discussion. It is the aim of this article to direct attention to a single point of this process, namely, the instant where probably for the first time there emerged a completely new point of view: the confrontation of mechanics with optics. It will be shown that the result of this confrontation was the recognition that the principle of relativity, closely connected with the fundamentals of mechanics, was called in question. It is therefore appropriate to dedicate this article to the memory of Wolfgang Pauli who, forty years ago, in December 1920, published his famous article on relativity theory in the *Mathematical Encyclopedia*.

The discovery that the principles of classical mechanics are entangled with the principles of optics was made by Euler in 1739. Or, as we can put it more precisely, he discovered that the decision between a wave and a corpuscular theory of light reflects on the validity of the principle of relativity. (Already in his *Mechanica*, published three years earlier, he had devoted the first chapter to an ample explanation of the difference between relative and absolute motion, cf. "Mechanica sive motus scientia analytice exposita", *L. Euleri Opera Omnia*, Ser. Sec. 1, 13.) In a paper of that year, he examines the aberration, discovered by Bradley in 1727, mainly in order to calculate corrections for astronomical use. The aberration is a systematic error in observing the stars, of the magnitude of 20″, which occurs through the Earth's movement in relation to the stars. Presuming that the fixed stars stay at rest, then three movements remain, of which the influence on the observation may be calculated: the daily rotation of the Earth, the yearly rotation of the Earth, and the movement of the planets. But, it is characteristic of Euler that he is not only interested in the special problem to which this examination gives rise, namely, the calculation of the required correction, but he rather attacks the question in its fullest generality as a physical problem. The astronomical calculation is only the starting point for investigating basic questions in mechanics, where the astronomical language is a mere fashion of presentation. Euler distinguishes four cases, which he examines one after the other: (1) the observer and the object are at rest; (2) the object moves; (3) the observer moves; (4) object and observer move.

For the second case he then derives the aberration formula. In the course of this, he notes that one may ask whether the velocity of light depends on the velocity of the radiant object (always measured in the rest system of the observer). But he himself gives the answer that this is not the case, since the propagation of light is a wave process in the stationary ether, which is independent of the movement of the emitting body, and he finds for the correction (I use Euler's notation):

$$\mathrm{tg}\alpha = \frac{ms}{c - \mu s}$$

where α is the angle between the observed and the true location of the object, c and s are the velocities of light and the object respectively, m and μ sine and cosine respectively of the angle between the light ray and the velocity of the object. He applies his formula to the simplest forms of movement (move-

* This article is an enlarged version of a chapter of the author's introduction to the forthcoming volume containing the papers referring to physical optics of *L. Euleri Opera Omnia*. Euler's article, "Explicatio Phaenomenorum quae a motu lucis successivo oriuntur", was published in the *Commentarii Academiae Scientiarum Imp. Petropolitanae*, Tomus XI ad annum MDCCXXXIX, but appeared only in 1750.

ment on a straight line and on a circle). Thereby he reaches the conclusion: to an observer at rest, the speed of a body in uniform and rectilinear motion seems to diminish more and more with increasing distance.

Now the third case, which for practical application is the most important: the object rests and the observer moves. Since Euler was one of the few authors who do allow the reader to participate in his investigations and to watch closely his paths, it might be worth while to report his reasoning in detail. For here it is possible for once to observe singly the steps through which a fundamental discovery is reached and to pinpoint as closely as possible the exact moment at which a crucial insight is gained.

He starts from the remark that one may reduce this case to the previous one by giving the system observer–object a speed which is equal but opposite to the original velocity of the observer. Therefore one may take over the formulæ derived above (that is, those derived in case 2) and apply them also to this case:

$$\mathrm{tg}\,\alpha = \frac{mr}{c - \mu r}$$

where r is now the velocity of the observer and m, μ are the sine and cosine respectively of the angle between the light ray and the direction of the observer's motion. This formula seems to settle the problem.

Euler, however, is not yet satisfied and wishes, as he says (section 20), "to investigate the effect which the light ray exerts on the eye in motion and the difference between the true and the apparent place according to the rules of motion". This investigation is essentially independent of the former and therefore a new derivation of the correction formula.

The velocity of light in the ether and the velocity of the observer are now added according to the rules of kinematics. Euler explains hereby his short trigonometric calculations amply with the help of his vector diagrams. But now one is surprised to find the astonishing result—the correction computed with this method differs from that found before: one gets:

$$\mathrm{tg}\,\alpha = \frac{mr}{\sqrt{c^2 - m^2r^2}}$$

instead of:

$$\mathrm{tg}\,\alpha = \frac{mr}{c - \mu r}$$

Euler asks: From where does this difference arise and which of the two answers, both the result of what appear to be rigorous derivations, is the correct one? First he remarks: it is clear that the difference arises from the fact that in the first derivation because of the reduction to case 2 we had implicitly assumed that the light velocity remains c, independent of the speed of the observer, whereas in the second derivation the light velocity becomes $y = \mu r + \sqrt{c^2 - m^2r^2}$.

The decision between the two correction formulæ therefore is reduced to the question, Which is the correct velocity of light? Euler now observes, the system under consideration comprises not only object and observer, but also the ether, which hence ought also to have received the same speed, which of course is excluded. In other words, the ether distinguishes an absolute system, and cases 2 and 3 are not equivalent but basically different. Equivalence between both cases, however, would hold in a corpuscular theory, as he points out, for in such a theory no ether distinguishes an absolute co-ordinate system and the principle of relativity (Euler says: "haec hypothesis . . . *motus compositionem* recipit", Section 28) prevails. (This is the point of departure for W. Ritz's attempt at corpuscular optics, in order to explain the negative result of the Michelson experiment. Cf. W. Pauli's article in the *Mathematical Encyclopedia*.) Therewith, Euler found what he had looked for; an 'experimentum crucis' which permitted at least in principle a decision between the two theories, wave and corpuscular optics. However, the difference is too small, as he notes explicitly, to be susceptible to experiment—in this case the astronomical measurement. Euler therefore calculates in his further investigations with his simpler formulæ which follow from the corpuscular hypotheses, since they coincide with those of the wave theory to within a difference of the second and higher order in v/c, that is, he makes full use of the principle of relativity (linear addition of the velocities).

This piece of work seems to me to be one of the most beautiful that Euler ever wrote; perhaps one may regard it as one of the classical papers in physics. This is not only because of its clarity and elegance, but also much more so for the peculiar manner in which a seemingly simple question gives rise to a discussion of the most basic principles of physics. At first one believes to have caught Euler with an error and one is then even more surprised by the infallibility with which he aims at the point which more than a hundred years later was to become the centre of discussion about the fundamentals of mechanics. How surprised, on the other hand, he would have been to learn that the decision had been made in favour of the principle of relativity and against the ether, and that this decision was made just on the grounds of the wave optics confirmed meanwhile by the Michelson experiment which is closely related to aberration! This might be another example of what W. Pauli used to call "the life of the ideas", "showing", as he formulates it in the preface to the second edition of his article, "how a fundamental scientific discovery, sometimes even against the resistance of its creator, gives birth to further fruitful developments following its own autonomous course". Though perhaps in this case one rather should say "even in a direction opposite to the intention of its creator. . . ".

From the following remark quoted from Section 35 of his paper, it is clear that Euler was well aware of the significance of the so-called systems of inertia as well as their peculiar problems: "licet enim salvis legibus et regulis *mechanicis* universo cuidam systemati corporum motum aequabilem in directum imprimere, eta, ut nil in phaenomenis mutetur, at vel motum inaequabilem vel curvilineam tribuere minime licet". This demand, namely, to regard the question not only as a kinematical but also as a physical one ("legibus et regulis *mechanicis*" . . .) should have saved him from being decried as having only a rather formal attitude towards physics. In this particular fashion of looking at those problems he remains the "true son of Newton", to quote C. A. Truesdell (cf. the introduction to vol. 8, Ser. Sec. of *L. Euleri Opera Omnia*, p. cxviii). However, just the mathematicians and sometimes even the physicists later on often overlooked this point, whereas Euler thought of the foundations of mechanics as subject to experimental examination. His explanations on how the

An invitation to subscribe to
this Important New Pergamon International Research Journal

INFRARED PHYSICS

This journal has been established as an international research journal for the publication of scientific papers concerning infrared physics and its applications. It is concerned with infrared theory, experiment, and instrumentation as applied to infrared detection and transmission and to problems of atmospheric, meteorological, geophysical, astrophysical and space research. Except as they pertain directly to infrared studies of planetary and stellar atmospheres, papers on molecular spectroscopy or spectrochemical analysis are considered outside the scope of INFRARED PHYSICS. The journal will contain Research Papers, specially invited Critical Surveys, quickly published Research Notes, and Book Reviews. The language preferred is English, but papers will be published occasionally in French and German. Manuscripts for editorial consideration should be sent to the Member of the Board of Editors most conveniently located.

CONTENTS OF VOLUME 1 NUMBER 1—JUST PUBLISHED

E. SCOTT BARR : The infrared pioneers-I. Sir William Herschel ; N. C. BEESE : Light sources for optical communication ; D. F. EDWARDS and M. MERCADO : Ultimate sensitivity and practical performance of the tellurium photoconductive detector ; S. NEILSEN, W. D. LAWSON and A. F. FRAY : Some infrared transmitting glasses containing germanium dioxide ; P. BRATT, W. ENGELER, H. LEVINSTEIN, A. MACRAE and J. PEHEK : A status report on infrared detectors ; H. HAPP and L. GENZEL : Interferenz-Modulation mit monochromatischen Millimeter-Wellen ; P. A. LAPP and H. S. KERR : Sunseeker for high-altitude infrared solar spectra ; H. KALLMANN, J. RENNERT and M. SIDRAN : Infrared photography using persistent internal polarization in phosphor plates ; C. HILSUM and W. R. HARDING : The theory of thermal imaging, and its application to the absorption-edge image-tube ; R. BEER and J. RING : A high-pressure scanning Fabry-Perot interferometer for the infrared ; T. S. MOSS and A. G. PEACOCK : Infrared optical properties of lead halides (Research Note).

To be Published Quarterly

BOARD OF EDITORS

N. MIGEOTTE

Université de Liège, Institut d'Astrophysique, Cointe-Sclessin, Belgium

T. S. MOSS

Royal Aircraft Establishment, Radio Department, Ambarrow Court, Lower Sandhurst Road, near Camberley, Surrey, England.

S. PASSMAN

The RAND Corporation, 1700 Main Street, Santa Monica, California, U.S.A.

W. K. WEIHE

U.S. Army, Engineer Research and Development Laboratories, Fort Belvoir, Virginia, U.S.A.

Assisted by an International Honorary Editorial Advisory Board

A copy of the journal and details of subscription rates gladly sent on application

PERGAMON PRESS

OXFORD LONDON NEW YORK

Headington Hill Hall, Oxford. 4 & 5 Fitzroy Square, London W.1. 122 East 55th Street, New York 22, N.Y.

No. 5000 PETROLOGICAL MICROSCOPE

Advanced student type of highest quality and workmanship.

Incorporating modern features.

Please write for full particulars.

R. & J. BECK LTD.

69/71 MORTIMER STREET, LONDON, W.1

Manufacturers of high grade microscopes for more than a century

GREEN'S PURE FILTER PAPERS

Always reliable year after year. Write for our free guide to the use of Filter Paper called N. "Signposts."

J. BARCHAM GREEN LTD.,
MAIDSTONE ENGLAND

GRAFLEX

The world's finest industrial cameras

CROWN GRAPHIC SPECIAL 45

The basic Graphic Camera for press and technical work. Built-in coupled rangefinder, parallax corrected optical viewfinder, rangelite for focusing in the dark and open frame finder. Double extension, rising, tilting and shifting front and Graflok back with Ektalite field lens.
CF.904 With 135 mm. f/4.7 Xenar in No. 0 Compur shutter.

CROWN GRAPHIC FLASH SPECIAL 45

C.F.905. As above, but including Graflite Junior flash-gun and connecting cord.

also **SUPER SPEED GRAPHIC**
PACEMAKER CROWN GRAPHIC
GRAPHIC VIEW

Manufactured by Graflex Inc., Rochester, U.S.A.

For further details and price list write to Sole Wholesale Distributors:

NEVILLE BROWN & CO. LTD. · 93-97 NEW CAVENDISH STREET · LONDON W1

speed of a moving object appears to an observer at rest are a first tentative prelude to Einstein's later criticism of time measurement.

There is an amusing question to be asked concerning the response to this paper. It was written by Euler in 1739, but its publication by the Academy of St. Petersburg was delayed until 1750. Meanwhile, he had published in 1748 a continuation to it in the *Mémoire de l'Académie des sciences de Berlin* (Mémoire sur l'effet de la propagation successive de la lumière dans l'apparition tant des planètes que des comètes, 1746. The volume was printed, however, in 1748.) There, however, he did not enter into the question: wave or corpuscular optics, but applied without further explanation the simpler formulæ of corpuscular optics as an approximation in the above-mentioned sense. A careful reader could have objected that Euler was in contradiction to the principles of his own wave theory, proposed and discussed in detail in his *Nova Theoria Lucis et Colorum* published in 1746.

Was there such a careful reader?

I received much encouraging criticism and various stimulating suggestions from Prof. A. Koyré. I am indebted to Dr. G. Barton for his linguistic advice. I wish also to express my gratitude to Prof. J. R. Oppenheimer and the Institute for Advanced Study for the generous hospitality offered to me.

THE BREEDING OF IMPROVED MILKING COWS THROUGH ARTIFICIAL INSEMINATION*

By Dr. J. EDWARDS and Dr. L. K. O'CONNOR
Production Division, Milk Marketing Board, Thames Ditton, Surrey

THE story of commercial artificial insemination in Great Britain is quite a short one, spanning, in fact, less than twenty years, for it was as recently as November 1942 that the first commercial artificial insemination (A.I.) centre was opened at Cambridge. In 1944, the Milk Marketing Board took over its first centre—Beccles—from the North Suffolk Cattle Breeders, and subsequent expansion was so rapid that by December 1958, only some fourteen years after acquiring its first centre, the Board's organization had inseminated a total of 10 million cows[1]. Now the 23 Milk Marketing Board and 6 non-Board centres, which together provide the artificial insemination service in England and Wales, inseminate more than 2 million cows a year, or approximately 60 per cent of the national herd. The Milk Marketing Board centres alone inseminate more than 1½ million cows a year, of which about 1 million are with semen from dairy and dual-purpose bulls.

In addition to the growth in the use of artificial insemination which is still continuing, there have been technical developments in the dilution and storage of semen, so that now one bull may be used for upwards of 10,000 inseminations a year, a figure which seemed impossible a short while ago, and the method is therefore well suited to the exploitation of a superior bull. Further, semen can be stored apparently indefinitely at a temperature of −79° C.; this facilitates transport and makes possible better utilization of semen.

The aim of the artificial insemination organization of the Milk Marketing Board is to breed cows capable of giving, economically, relatively high yields of milk of satisfactory quality as regards composition. Since in Britain at the present time milk is paid for on the basis of quantity, milk yield is a characteristic of major importance; but the milk produced must satisfy certain minimum standards of composition and therefore the quality must also be taken into account in selection. It is also necessary that the cows should be capable of economic milk production; in other words, their conformation must be such that they are capable of a long trouble-free life in the herd, they must have a satisfactory temperament, be easy to milk and so on. These factors which go to make an economic cow can only be assessed subjectively, so here we will discuss only milk yield and fat percentage, which are recorded in National Milk Records, the official milk-recording scheme in England and Wales.

The production characteristics, milk yield and fat percentage, are only expressed in the female, and, moreover, the heritability of milk yield is low, being of the order of 0·3. In this situation it is clear that the breeding worth of a bull must be assessed by means of a progeny test, even though as a result the generation interval is increased; for although a bull can be used when he is a year old, he is about six years of age before the result of a progeny test can be obtained even in favourable circumstances. A further problem in assessing a bull's genetic merit for milk yield is that as much as 90 per cent or even more of the differences in level of production between herds are due to environmental factors. This means that the average yield of a bull's daughters may be a reflexion of the environment under which they were milked rather than of the breeding worth of the bull. It was to combat this situation that the contemporary comparison method of bull evaluation was introduced[2–4]. This entails a series of comparisons within herd-years between the average first lactation milk yield of the daughters of the bull and the average yield of their contemporary heifers by other bulls, each comparison being weighted according to the number of daughters and contemporaries. The weighted differences from the separate herd-years are then combined to give a single figure for the bull, which is the mean weighted difference between the first lactation yields of the daughters of the bull and their contemporaries. The total weight on which it is based is a measure of the accuracy of the test. The accuracy of a contemporary comparison can, in fact, be expressed in terms of the total weight (W) and the heritability of single records (h^2) as $\frac{W}{W + (4 - h^2)/h^2}$, which reduces to $\frac{W}{W + 12{\cdot}33}$ when a heritability of 0·3 is assumed[5]. This fraction may vary from zero for no information to 1 for

* Substance of a paper read at the 135th meeting of the Genetical Society on March 23.

complete information about the bull's breeding worth, and it increases as W increases.

The weighting is not, however, the only factor to be taken into account in assessing a bull for milk yield. The general applicability of a contemporary comparison rests on the assumption that the contemporary heifers are genetically average for their generation. This may reasonably be assumed to be the case where a bull has been used in artificial insemination and his daughters are consequently scattered through a large number of herds where the contemporary heifers are by many bulls; and it has been found that in these circumstances the contemporary comparison behaves in practice more or less as would be expected in theory. A natural service bull, however, usually has most of his daughters in a single herd, where the contemporary heifers are likely to be by very few, perhaps even by only one, sire. Although the resulting contemporary comparison may not be generally applicable, the method is not useless in such a situation. Indeed, it probably has its greatest value when the daughters of a bull milk mainly in one herd, since it is in these conditions that the environment is likely to have its greatest effect on the average production of a bull's daughters.

In the case of fat percentage, the situation is simpler. The heritability is higher than for milk yield, being about 0·5 as compared with that for milk yield of 0·3; more important, however, is the fact that environmental differences between herds do not affect fat percentage to the same extent as they affect milk yield, so that the average fat percentage of a bull's daughters may be used to assess his breeding merit for this characteristic. The accuracy of a progeny test for fat percentage is $n/(n + 7)$, where n is the number of daughters of the bull. Therefore, 7 daughters will give a progeny test for fat percentage with an accuracy of 0·5, whereas a weighting of 12·33 or approximately 18 daughters are required to give a progeny test for milk yield of the same accuracy.

A bull in artificial insemination can generally be tested through his progeny more accurately than a bull in natural service, both by virtue of his having a greater number of daughters and because these daughters are scattered through a large number of herds. He will also generally be younger when his progeny test assessment is first available. In order to make the best use of the superior bulls which are found, they must be used not only to breed females but also to breed bulls to enter the artificial insemination stud for progeny testing in their turn. In other words, the artificial insemination population must be genetically closed, at least to some extent. The Milk Marketing Board has for some time been using its best bulls to breed sons out of cows with at least four lactations which have proved to have outstanding individual performances in their own herds and which have been approved for conformation, temperament, etc., by a panel of breeders. It has been shown[6] that a large number of young bulls bred in this way will on average be of greater genetic merit than the population as a whole, and by progeny testing it is possible to select the best from this superior group. However, such selection within a closed population is inevitably accompanied by inbreeding, and the question arises of how far one can go in closing an artificial insemination population or in limiting its size.

In practice, because of the long generation interval, the problem is not pressing; but nevertheless it is one which merits early consideration, and in order to obtain a consensus of opinion, the proposition that "2 million dairy cattle may be bred annually to 200 sires of known breeding merit without genetic deterioration" was put to a number of geneticists, both in Britain and overseas[7]. Their replies were generally favourable.

In considering the problem, two facts must be borne in mind. First, that the artificial insemination population is divided into a number of breeds (the Milk Marketing Board gives service from nine dairy and dual-purpose breeds) varying in importance from Friesians, where about 735,000 cows a year are inseminated, to Northern Dairy Shorthorns, where just over 1,000 cows a year are inseminated. Secondly, milk records are kept for only a minor proportion of cows bred by artificial insemination; the proportion varies with breed and area of Britain, but averages between 15 and 20 per cent, which reduces substantially the effective size of the female population. The consequences of inbreeding in dairy cattle are a reduction in yield, viability and fertility, and Robertson[8] has estimated that there is a fall of 0·32 per cent of the original yield for every 1 per cent increase in the inbreeding coefficient. A small degree of inbreeding is therefore unlikely to have serious consequences, but steps must be taken to ensure that the coefficient of inbreeding does not rise to too high a level. There are three main ways in which this can be done:

(1) A degree of diversity can be maintained by limiting the number of sons by any one bull. This would certainly result in a low rate of inbreeding, but it would also limit the amount of selection which could be applied, and is therefore not a very attractive proposition.

(2) Alternatively, bulls could be introduced from outside the system from time to time but not used extensively until their breeding worth was known. The Milk Marketing Board has been doing this since the inception of its artificial insemination service and will certainly continue to do so for a variety of reasons. However, if, as it should, the average genetic merit of the artificial insemination population rises more quickly than that of the natural service herds, it will become increasingly difficult to find superior bulls from outside the artificial insemination group.

(3) A third possibility is to divide the population into several isolated or semi-isolated groups, so that strains within the breed are formed. This system certainly has a number of genetic advantages, one being that although the different sections of the artificial insemination population would be moving towards the same goal, they would not necessarily be travelling by the same route, so that a degree of genetic diversity would be maintained.

Again, because of the long generation interval in cattle, the exhaustion of genetic variability as a result of continued inbreeding is a secondary problem; but it is possible to safeguard against it by maintaining supplies of frozen semen, so that if necessary some of the genetic variation which has been lost can be re-introduced. In doing so, however, some of the superiority in economic characteristics built up by selection would be lost.

Another danger of inbreeding is that of increasing the frequency of undesirable recessive genes in the population. A bull may be tested for simple recessives either by mating him to 23 of his own daughters, when there is a 95 per cent chance of detecting the 'carrier' bull, or by checking on any abnormal calves

resulting from approximately 600 outbred matings when, provided that the frequency of the recessive gene in the population is 1 per cent, there is again a 95 per cent chance of detecting the heterozygous bull.

For the progeny test of young bulls, the Milk Marketing Board carries out 500 inseminations in recorded herds and 500 in non-recorded herds, and these should result in approximately 600 calves being born. Thus if the existing reporting system can be improved, it should be possible to detect the majority of those bulls carrying deleterious recessive genes of importance in the population without resorting to sire–daughter matings. This is the procedure which is favoured. It is true that sire–daughter matings will enable the detection of any recessive gene whatever its frequency, but they are difficult to organize in practice, and therefore it is proposed to carry them out only in exceptional cases.

[1] Milk Marketing Board, *Breeding 10,000,000 Cattle* (1959).
[2] Robertson, A., and Rendel, J. M., *J. Agric. Sci.*, **44**, 184 (1954).
[3] McArthur, A. T. G., *Proc. Brit. Soc. Anim. Prod.* (1954).
[4] Robertson, A., Stewart, A., and Ashton, E.H., *Proc. Brit. Soc. Anim. Prod.* (1956).
[5] Robertson, A., *Biometrics*, **11**, 95 (1955).
[6] Robertson, A., *J. Agric. Sci.*, **54**, 100 (1960).
[7] *Genetic Considerations in Breeding Two Million Cattle to Two Hundred Sires* (privately printed, 1959).
[8] Robertson, A., *Proc. Brit. Soc. Anim. Prod.* (1954).

OBITUARIES

Academician A. F. Joffé

THE death on October 14, 1960, of A. F. Joffé, one of the pioneers of physics in the U.S.S.R., member of the Russian and many other Academies, is a severe loss for science. Joffé took a most active part in the remarkable and violent development of physics from the dawn of the twentieth century up to the present time. To the last day of his life he never ceased experimenting with his own hands.

Joffé's early work (1907–13) was devoted to experimental substantiation of the quantum theory set out by Einstein in 1905 while investigating the photoelectric effect and photochemical phenomena. The theory provoked at first adverse comments on the part on many eminent physicists (Ladenburg and others). In 1907 Joffé undertook a theoretical treatment of experimental results obtained by Ladenburg and others, and proved convincingly that Einstein's photon theory was not contrary to, but on the contrary justified by, all experimental data, including those of Ladenburg.

Joffé's experiments on the photoelectric effect exhibited in metal dust suspended in the electric field of a condenser provided direct confirmation for Einstein's theory. Joffé showed that under illumination a dust particle loses its electric charge by portions corresponding to the electron charge, the nature of the process being statistical and in keeping with that of the photon theory. The same experiments supported the atomistic theory of electricity. The conditions of Joffé's experiments were somewhat similar to those of R. A. Millikan, who followed the behaviour of oil droplets suspended in an electric field and showed that all fluctuations in droplet charges were multiple integers of the elementary electric charge. The experiments of Millikan and Joffé were conducted simultaneously and independently, and were published in 1911 (Millikan) and 1912 (Joffé).

In 1913 Joffé published his results on the magnetic field of the cathode beam. The occurrence of a magnetic field around the cathode beam was still uncertain at the time. The mere fact was denied by many scientists. Besides providing confirmation for the occurrence of the magnetic field, Joffé succeeded in showing that the field intensity was akin to that of an equivalent current in a metal conductor.

At the beginning of the 'twenties, the advent of quantum mechanics, Joffé reverted to his 1912 experiments and found that metal dust particles irradiated by X-rays emitted electrons. These experiments, carried out with Dr. Dobronravov, gave convincing proof that the energy of electrons emitted by dust particles corresponds to that of X-ray quanta.

However, the main trend of Joffé's theoretical and experimental works throughout his life was in the direction of electrical and mechanical properties of dielectrics and semi-conductors. He may with full justice be considered among the pioneers of the physics of solids. His earliest scientific investigations dealt with elastic and electric properties of quartz. In 1922, while investigating the plastic strain in crystals, Joffé and Kirpicheva discovered that the spots of the Laue diffraction pattern were extended into radial stripes as soon as the elastic limit was exceeded. This was evidence that plastic strain leads to the breaking up of a crystal into differently oriented blocks.

Joffé's disciples extended his investigations to a great variety of crystal bodies, and their work obtained world-wide appreciation. A new trend in the physics of metals arose and was successfully developed.

Another line of experimental investigation pursued by Joffé provided a basis for the theory of crystal strength. Prior to these experiments there was a large discrepancy between the values of crystal strength obtained experimentally and those calculated on the crystal lattice theory. For example, the theoretical limiting value for rocksalt crystals was found to be several hundreds of kgm./cm.^{2}, whereas experiment gave a limit of hundreds of gm./cm.^{2}. Measurements of rocksalt crystals immersed in water and similar experiments carried out with balls of rocksalt cooled in liquid air which were immersed in boiling water or molten tin showed that under these conditions the limiting strength was close to the theoretical order. The low limit observed before was ascribed to microcracks and other crystal defects.

Another important discovery was made by Joffé when investigating the mechanical properties of crystals. He found that the nature of brittle or plastic destruction of crystals at a given temperature was determined by the relation between the temperature-dependent yield strength and the ultimate tension which is only slightly dependent on temperature. This relation, established later for a number of industrial materials, led to many conclusions of great practical value.

Of extreme importance were Joffé's investigations on electric properties of dielectrics. Prior to his experiments, all electric phenomena displayed by dielectrics were considered as a sort of agglomeration of anomalies. Joffé found that thin polarization layers were formed at the electrode surfaces during the passage of current through a dielectric crystal. The potential difference of these layers appeared to be enormous. By allowing for polarization, Joffé showed that the flow of current through a crystal was in strict obedience to Ohm's law. Joffé was the first to discover (in 1916) that the conductivity of the majority of ionic crystals was of an electrolytic nature and due in part to lattice-occluded impurities and in part to thermal dissociation of the lattice.

Joffé and his disciples have conducted a vast amount of work on dielectric breakdown, in particular on breakdown stress as a function of the thickness of the dielectric material. These investigations were of great importance for the technology of insulating materials.

From 1930 Joffé's interests began to concentrate on semi-conductors. Even then, Joffé was aware of the importance of semi-conductors for engineering problems. Joffé himself and his co-workers were very successful in this field and discovered a number of fundamental facts in the physics of semi-conductors. First of all considerable attention was paid to the working out of techniques for obtaining physical values characteristic of semi-conductors, such as the concentration of carriers, their charge, mobility, etc. Most important was the discovery of the effect of impurities on electric properties of semi-conductors. It was shown, moreover, that an excess or a deficiency in some component may exhibit an effect similar to that of an impurity. It appeared, for example, that lead sulphide containing an excess of lead atoms was a conductor of the *n*-type, whereas a sulphur excess would make it *p*-type. Joffé suggested that these facts were due to impurity or excess atoms either creating additional electron sources or picking up electrons with consequent formation of holes. The concept of electron-or hole-semi-conductors, now defined as *n*- and *p*-type, seems to have originated from Joffé's laboratory.

Towards the end of the 'thirties Joffé, together with his wife, proposed a mechanism of rectification which is now widely accepted. It implies that the barrier-layer in rectifiers is formed at the *p-n* junction. The flow of current is due to electrons and holes approaching each other and recombining at the junction. When the electrons and holes drift apart, the resistivity of the layer adjacent to the junction is raised and the latter consequently becomes a barrier-layer.

Of the many practical applications of semi-conductors Joffé considered as paramount the utilization of their thermoelectric and photoelectric properties for conversion of heat and light energy into electric energy. Joffé's theory of thermoelectric generators (and thermoelectric refrigerators) opened a clear path for physicists and engineers working in this field. The idea of plasma thermoelectricity, now being developed in many countries, was also set forth by Joffé.

His great achievements in this domain were emphasized by the eminent American scientist J. Bardeen at the International Conference on the Physics of Semi-Conductors in Rochester, 1959. In his inaugural speech Bardeen said: "The first real scientific study of electron mobility, thermal conductivity, and other factors important for thermal elements, and the way they depend on composition was made by Joffé and his co-workers. Results they have obtained clearly demonstrate the virtue of the scientific over the purely empirical approach. . . . . Research on thermoelectric effects and on thermal conduction in semi-conductors has yielded a number of interesting phenomena, involving phonon scattering, phonon drag, and heat transfer by ambipolar diffusion".

A profound and eager concern for all problems of physics and adjacent fields was very characteristic of Joffé as a scientist. A great number of Joffé's ideas, developed later by his disciples, date back to the 'twenties and 'thirties; they laid the foundation for the development in the U.S.S.R. of modern trends of physical science. Joffé acknowledged his authorship only in investigations that were carried out with his own hands. He was never prone to put his name to papers dealing with investigations that were carried out by his numerous disciples, even though the ideas and guidance were his. This makes his contribution to science, embracing a great variety of physical fields (nuclear physics, chemical physics, the theory of metals, physics of heat, etc), even larger than it would seem at first.

He created a widely spread school of Soviet physicists dealing with most diverse trends in physics and related sciences. His gift for inspiring his colleagues, especially young ones, with a passionate interest for science was truly remarkable.

Sixteen new institutes were founded under Joffé's sponsorship. In 1918 he created the Physico-Technical Institute of Leningrad, which played an exceptionally important part in the development of physics. He was director of this Institute for more than thirty years, but his activities reached far beyond its scope. He took part in the development of physics all over the country, and his was the idea of a widely spread system of physico-technical institutes and laboratories that would serve as a scientific basis for the growing industry. He contributed largely to the organization of physical institutes in Kharkov, Dnyeporpetrovsk, Tomsk, Sverdlovsk. Groups of able scientists were chosen by him from his staff for work in each of these institutes, thus forming the nuclei of future scientific bodies. The Institute of Chemical Physics in Moscow and the Electro-Physical Institute in Leningrad sprang up from the Leningrad Physico-Technical Institute. The Institute of Physical Agriculture, so far the only one of its kind, was also founded by Joffé. An outstanding Physico-Mechanical Department of an entirely novel type was created by Joffé in the Leningrad Polytechnic Institute. Its programme combines deep penetration into theory with most lively actual practice. Engineers coming from this department possess a profound knowledge of modern physics and are carrying the latest scientific achievements to all fields of industry.

Joffé's remarkable personality, his immense scientific prestige and wide erudition, his unquenchable passionate love for science, his gift for inspiring his disciples, his rare simplicity and affability won him respect and affection among the widest circles of scientists and engineers of the Soviet Union, deep friendship on the part of his disciples, including the present writers. The strongest bonds of friendship tied him with eminent scientists of many countries. It will be hard for all who knew him to accept the fact that he is no more, that the hearty man who

seemed unaware of age, so full of the joy of life and far-reaching projects, has gone, that the tireless, wonderful intellect has ceased to exist.

N. N. Semenov
V. N. Kondratiev

Prof. C. W. Dannatt

Prof. Cecil William Dannatt, who died at his home in Blackheath on April 9, was born on August 2, 1892. He was educated at Colfe's Grammar School and the Royal School of Mines, where he graduated in metallurgy in July 1914. In August of the same year he enlisted in the Queen's Westminster Rifles. He received a commission in 1915 and served in France, Salonika and Palestine. On being demobilized in 1918, he joined the Ministry of the Interior, Cairo, as assistant director of the Technical Section of the Public Security Department. After two years of very varied experience in this post, he went to Trinidad as geologist to an oil company, but in 1923 he returned to the Royal School of Mines, to work as a research student in the Metallurgy Department. A few months later he joined the teaching staff of the Department, and the work was so much to his liking, and he so well fitted for it, that he remained on the staff for thirty-four years, first as demonstrator, then lecturer, reader, acting director and finally, from 1945 until his retirement in 1957, professor and head of the Metallurgy Department.

Throughout his long connexion with the Royal School of Mines and Imperial College, and particularly after his appointment as professor, he devoted himself to the advancement of the Department, and the training and education of his students, in every one of whom he took a personal and sincere interest. Under his leadership, the Department added continuously to its reputation as a centre of learning and research, and when he handed over to his successor in 1957 he was able to do so in the knowledge that its standing had never been higher. Although his interests and knowledge extended to all branches of metallurgy, and he was a vigorous opponent of specialization within his Department, his greatest interest was in fact in the scientific and technological aspects of the extraction of metals from their ores, and the achievement that afforded him more gratification than any other was the formation of the Nuffield Research Group in Extraction Metallurgy. He was largely responsible for the establishment of this group in his Department in 1950, since when, with his active support, it has developed into the leading academic research school devoted to the study of metallurgical processes at high temperatures.

Prof. Dannatt had a charming and gracious personality, and he was an unsparing worker. He was always anxious to help, and always reluctant to refuse any request for advice or information, or demand for his services. Scientific societies, professional institutions, educational and examining bodies, and Government, college and university committees made many such demands not just on account of his position but also because his wide knowledge, alert mind and ability to express himself lucidly and concisely were powerful assets in committee work. He particularly valued his long association with the Institution of Mining and Metallurgy, of which he was president during 1956–57, the Institution of Metallurgists, of which he was vice-president during 1953–57, the Sir John Cass College and Woolwich Polytechnic, as member of their governing bodies, and the City and Guilds of London Institute, as member of the General Advisory Committee and Moderating Committee for Metallurgical Subjects.

Shortly after his retirement, the title of professor emeritus of metallurgy was conferred on him by the University of London, and in 1960 he became a Fellow of the Imperial College. Although incapacitated by a prolonged and severe illness, he retained his interest in metallurgy to the end. He is survived by his widow and daughter.

M. S. Fisher

Prof. J. Bordet, For.Mem.R.S.

Jules Bordet, who died at his home in Ixelles in Belgium on April 6, was a pioneer in the science of microbiology and the allied one of immunology. The last twenty-five years of his life—he died at the age of ninety—were spent in retirement and he had used the early years of this period of leisure to prepare a second edition of his excellent text-book, *Traité de l'Immunité dans les Maladies Infectieuses*, which appeared in 1939. But in the closing years of the past century and the first thirty years of this one, Bordet's brilliant mind and experimental skill led to discoveries of fundamental importance and a flow of scientific papers which established for him an indisputable claim to fame.

Bordet was born in Soignies, Belgium, on June 13, 1870. Electing to enter the profession of medicine, he studied at the University of Brussels, graduating M.D. in 1892. Choosing a laboratory career, he went to the Pasteur Institute, Paris, in 1894, and worked there for seven years, being recalled in 1901 to become first director of the newly founded Pasteur Institute, Brussels. Six years later he was appointed to the chair of bacteriology in the University of Brussels, holding this post until his retirement in 1935.

Bordet's inquiring mind led to his study of many aspects of microbiology, among others, anaerobiosis, bacterial agglutination, the pleuropneumonia group of micro-organisms and the bacteriophages, on all of which he made valuable original observations. It was, however, his investigations into the ætiology of whooping-cough and his elaboration of the complement-fixation test, in both of which he had the assistance of his colleague, Gengou, that stood out above the rest. It was he and Gengou who, in 1906, discovered the causal agent of whooping-cough—*Haemophilus pertussis*—a discovery which has made possible the specific prophylaxis of this disease; and it was at the end of the last century, in 1895 to be precise, that he published his first paper on bacteriolysis, showing that lysis of a bacterium by an immune serum was the work of two serum components, specific heat-stable antibody and non-specific heat-labile complement. It was from this observation, of course, that the complement-fixation test emerged (1901), with its wide application in the diagnosis of disease.

Recognition of the value of these researches brought Bordet many honours. In 1911 he was given the Prix de la Ville, Paris, and two years later the Swedish Medical Society awarded him the Hansen Prize and the Pasteur Medal. He was made a foreign member of the Royal Society in 1916, and in 1919 he was given the Nobel Prize for medicine and physiology; the University of Cambridge conferred on him the honorary degree of M.D. Bordet was married and had three children, a son and two daughters.

S. P. Bedson

NEWS and VIEWS

Medical Statistics in the London School of Hygiene and Tropical Medicine: Prof. A. Bradford Hill

Prof. A. Bradford Hill retires from the chair of medical statistics at the London School of Hygiene and Tropical Medicine at the end of the current academic year. As a son of the late Sir Leonard Hill he has inherited perspicacity and sharpness of wit, but he has made his own very distinctive contributions to medicine and to statistics. He joined the staff of the Medical Research Council and its Industrial Health Research Board in 1923, and soon immersed himself in problems of industrial sickness. His surveys of sickness in the cotton spinning, cotton weaving and printing industries immediately became standard references, and early in this period he read to the Royal Statistical Society a classical paper on the effect of internal movement of population on local mortality. In 1933, Hill became reader in epidemiology and vital statistics in the University of London and set himself to understand doctors and their problems and to teach them what he calls "arithmetic with logic". He was pre-eminently successful in both tasks. In 1937, he published *Principles of Medical Statistics*, a text-book which still occupies an unchallenged place, is in its sixth edition in English and has been translated into other languages. Since 1945, Hill has been professor of medical statistics in the London School of Hygiene and Tropical Medicine and director of the Statistical Research Unit of the Medical Research Council. His interest and experience in the conduct of the controlled clinical trial are probably unique, and he has set very high standards for his unit. Any research worker who survives Hill's devil's advocacy can be sure his experiment is properly designed; he can also be sure of warm encouragement and help. Hill has been widely honoured, being elected a Fellow of the Royal Society (1954), president of the Royal Statistical Society from 1950 until 1952 (to which he gave much time and energy as honorary secretary during 1940–50) and its gold medallist in 1953; president of the Section of Epidemiology, Royal Society of Medicine 1953–55, and member of the International Statistical Institute.

Prof. P. Armitage

Dr. Peter Armitage who, at thirty-seven, succeeds Prof. Bradford Hill in the chair of medical statistics is a mathematical graduate of Cambridge. His studies were interrupted by the War and he went to the Ministry of Supply Statistical Advisory Department during 1943–45, and later to the Mathematics Division of the National Physical Laboratory. In 1947 he joined the Statistical Research Unit of the Medical Research Council. Dr. Armitage has contributed much to recent advances in mathematical statistics, especially in their application to prophylactic and therapeutic trials. In particular he has developed the sequential method as a highly effective tool and has recently published an excellent text-book, *Sequential Medical Trials*. Dr. Armitage is, like his predecessor, unstinting in his efforts to further the cause of the Royal Statistical Society; he has been a member of the Council since 1954 and an honorary secretary from 1958.

Pharmacy at the Royal College of Science and Technology, Glasgow: Prof. J. P. Todd

Prof. James P. Todd, who retires at the end of this session, was appointed to the newly constituted School of Pharmacy in the Royal College of Science and Technology, Glasgow, in 1921 as its sole lecturer. The growth of the School to its present proportions is a remarkable tribute to his foresight and able direction. The first courses offered were those leading to the examinations of the Pharmaceutical Society, but in 1924 the first student was enrolled for the degree of B.Sc. in pharmacy of the University of Glasgow, which had been instituted in 1907, and teaching for this degree began in the School under the Ordinance of Affiliation. Todd was awarded a Ph.D. in 1932, and in 1937 was appointed professor of pharmacy, this being the first chair of pharmacy in the United Kingdom. His responsibilities also included the Departments of Botany and Bacteriology, and the Scottish School of Bakery. Much of the credit for the development of these disciplines to the status of full departments with separate chairs in food science and in applied microbiology and biology belongs to Prof. Todd. No record of his achievements would be complete without mention of his work during the War years, when infusion fluid and blood transfusion units were set up in the College under his direction. The permanent West of Scotland Region Blood Transfusion Service stands as a lasting reminder of this period of his career. His studies of bacterial pyrogens, which later became a major interest, stemmed directly from this work, and he is now recognized as a leading authority on this subject.

Prof. J. B. Stenlake

Dr. John B. Stenlake, who is to succeed Prof. J. P. Todd, was educated at Ealing Grammar School. He then served an apprenticeship in pharmacy before proceeding on a Jacob Bell Memorial Scholarship to the College of the Pharmaceutical Society, where he qualified as a pharmaceutical chemist in 1941 and was awarded the Pereira Medal. After war service in the Royal Air Force, he joined the teaching staff of the School of Pharmacy of the University of London, and during this period graduated B.Sc. with honours in chemistry. In 1950 he was awarded a Ph.D. degree by the University of London and a D.Sc. (London) in 1960, for work in the field of medicinal and pharmaceutical chemistry. Since 1952 he has held the appointment of senior lecturer in pharmaceutical chemistry in the School of Pharmacy of the Royal College of Science and Technology. He will take up his new post on September 1.

Applied Microbiology and Biology at the Royal College of Science and Technology, Glasgow: Prof. E. O. Morris

Dr. Ernest O. Morris has been appointed to the new chair of applied microbiology and biology at the Royal College of Science and Technology, Glasgow, and will take office as from September 1. Dr. Morris was educated at the Handsworth Junior Technical School, Birmingham, and, during 1929–39, worked as a laboratory technician in a hospital and in the Departments of Cancer Research and of Pathology

and Bacteriology in the University of Birmingham. During this time he qualified as an associate of the Institute of Medical Laboratory Technology. In 1939 he was mobilized with the Territorial Army and served with the Royal Army Medical Corps in France, Assam and India. Later he served on the staff of General Headquarters at the Central Military Laboratory, Poona, where he assisted in the training of army personnel in medical laboratory technology. After demobilization he matriculated at the University of Birmingham, where he graduated with honours in bacteriology in 1950. In 1952 he was awarded a Ph.D. at the University of Birmingham for work on the bacterial flora of the mouth in relation to dental caries. Following this he became head of the Microbiological Division at the Brewing Industry Research Foundation under the directorship of Sir Ian M. Heilbron, a post he held until 1956. During this period his own research interests ranged from fundamental studies of the physiology of yeasts to the development of techniques for use in the fermentation industries. In 1956 he was appointed lecturer in the Microbiological Division of the School of Pharmacy, Royal College of Science and Technology, and principal lecturer in that Division in 1959. When the Divisions of Microbiology, Biology and Biochemistry in the School of Pharmacy were formed into the Department of Applied Microbiology and Biology, Dr. Morris was appointed head of the new Department.

Zoology at the Banaras Hindu University: Prof. S. P. Ray-Chaudhuri

Dr. S. P. Ray-Chaudhuri has been appointed to the chair of zoology at the Banaras Hindu University, Varanasi, India. He obtained his Ph.D. in the University of Edinburgh, working with Prof. H. J. Muller on the effects of radiation on the fruit-fly *Drosophila*, and has been engaged in teaching at the University of Calcutta since 1941. Dr. Ray-Chaudhuri was elected a Fellow of the National Institute of Science of India in 1950, and was the president of the Zoological Section of the Indian Science Congress in 1960. He is well known for his contributions to radiobiological research.

Commonwealth Technical Training Week

In Great Britain, Commonwealth Technical Training Week is to be held during May 29–June 3, 1961. In Aden, Hong Kong, Nigeria, Malaya and Pakistan the week will have been celebrated before this date and will have carried appropriate messages from H.R.H. the Duke of Edinburgh. In the United Kingdom support is almost universal. In England and Scotland possibly seven areas may not take part, but both Wales and Northern Ireland have each achieved 100 per cent participation. A special exhibition at the Royal Exchange, London, is being arranged by the City and Guilds of London Institute in co-operation with the City of London, the City Livery Companies and the London County Council. The exhibition will illustrate the opportunities for training and education in industry, commerce and the professions. Most of the exhibits will be provided by organizations which are nationally representative of the major groupings in industry and commerce, while the City Livery Companies will provide exhibits illustrating the historic background of training and craftsmanship. The Duke of Edinburgh has recorded a short address for use at the opening ceremonies. His Royal Highness, speaking from the dairy at Windsor Castle, has also contributed a lively introduction and epilogue to the film "Training To-day for To-morrow".

U.S. Antarctic Research Ship *Eltanin*

The U.S.N.S. *Eltanin*, an ice-strengthened cargo ship, is to be equipped as a sea-going scientific laboratory for the U.S. Antarctic Research Programme. It is expected that the first research cruise will begin in the later autumn of 1961. The ship will be fitted to accommodate numerous disciplines, including meteorology, upper atmosphere studies, marine and terrestrial biology, physical oceanography, submarine geology, and geomagnetic studies. The cost of conversion will be borne principally by the National Science Foundation; the Military Sea Transportation Service will supervise the ship's modification. The *Eltanin* will continue to be owned and operated by the Military Sea Transport Service. The National Science Foundation, as sponsor of the ship, will be responsible for the scientific programme and will designate a senior scientist aboard. It is expected that the ship will work in Antarctic waters at least ten months a year. Individual cruises will vary from one to two or more months in length, depending on the research in progress. During refuelling calls at southern hemisphere ports, scientists will be able to change equipment for experiments.

British Leather Manufacturers' Research Association : Open Days

The work exhibited during the 1961 open days (May 2–4) in the laboratories of the British Leather Manufacturers' Research Association at Milton Park, Egham, mostly showed developments from last year's programme (see *Nature*, **186**, 1024; 1960). Work on the mechanical properties of collagen and leather fibres has continued. An automatic amino-acid analyser (Bender and Hobein) has been installed for work on the protein constituents of skin. A synthetic approach to tanning chemistry, involving the preparation of phenolic glucosides and sugar esters, has been commenced. Considerable progress has been made in the use of enzyme preparations in place of the traditional milk of lime plus sodium sulphide bath, for loosening hair or wool in preparing skins for tanning. The work (sponsored by the U.S. Department of Agriculture) on the deterioration of leather by perspiration and warm, damp conditions has also advanced considerably, and some aspects of the problem have been solved. In the section on dyeing, two topics were illustrated: improving regularity of shade by finding how to control the dyeing process more precisely and improving the products from the users' point of view, for example, the problem of loose colour in suede leather. Development of performance trials for assessing the reliability of laboratory tests of physical properties has continued, particularly in the work on waterproofing leather. The 'effluent liaison' section, which advises on the application of existing knowledge to the effluent problems of the leather industry (*Nature*, **187**, 992; 1960) is now in full operation and the apparatus used by the mobile laboratory was shown. A substantial part of the Association's effort is devoted to liaison activities (member services) of various kinds, and between 700 and 800 production problems are investigated each year for member firms.

British Hat and Allied Feltmakers Research Association

The thirteenth annual report of the Director of Research, British Hat and Allied Feltmakers Research Association, covering the year ended August 1960, refers to considerable effort in the production of control charts for members (Pp. 20. Droylsden, Manchester: British Hat and Allied Feltmakers Research Association, 1961). Work on the storing of carroted rabbit skins was continued, and a literature survey of information published on the carroting of fur during the past ten years was issued to members. Work also continued on the possible applications to fur felt of classes of dyes other than the acid-levelling type, and acid-milling and the 1 : 1 and 1 : 2-premetallized colours have been applied successfully on a small-scale cone-dyeing machine with the aid of proprietary dyeing assistants, giving improved fastness properties. Work on the effect of pressure, moisture and temperature on pressing performance has led to the definition of limits for each, and the limits of accuracy required in the dimensions of blocks and press-dishes to give specified hat sizes have also been studied and defined. A start has been made on the measurement of the coefficient of friction of wool felt with other materials when immersed in water and aqueous solutions, and results obtained in measurements of the shock absorption behaviour of felt against other materials, such as sponge rubber and foam plastics, are being analysed to resolve differences which are believed to be fundamental to the problem of shock absorption.

Protection of Workers against Unsealed Radioactive Substances

Requirements for the protection of persons employed in factories (and other places to which the Factories Act, 1937, applies) against ionizing radiations and other hazards arising from the use of unsealed radioactive substances are set out in a recent publication issued by the Ministry of Labour (*Unsealed Radioactive Substances Regulations (Preliminary Draft of Regulations)*. Pp. 28. (London: H.M.S.O., 1961.) 1*s.* 3*d.* net.) This draft, called the 'Unsealed Radioactive Substances Regulations', is a complementary code to the statutory draft of regulations recently published dealing with the protection of workers from dangers arising from the use of 'sealed sources' of radioactive substances, and from machines which produce ionizing radiations. It has been prepared by the Ministry of Labour with the help and advice of an *ad hoc* committee appointed to advise the Chief Inspector of Factories on the subject, by the Advisory Panel on Radiological Problems in Industry, and by the General Purposes Committee of the Radioactive Substances Advisory Committee. The proposed regulations will apply to the whole range of radionuclides used in industry, including those used in nuclear reactors, and they will, in time, replace the 'luminizing regulations' made in 1947. Unsealed radioactive substances are defined by the regulations to include nuclear fuel-elements. Maximum permissible doses, based on the recommendations of the International Committee on Radiological Protection, and supported by the Medical Research Council, are laid down. Provision is made for reliance to be placed on working arrangements that provide intrinsic safety, for the instruction of workers concerned with the hazards involved and the precautions to be taken, and also for medical supervision. The Ministry invites observations on the draft regulations. These should be sent to 8 St. James's Square, London, S.W.1.

Rise in Population in Britain

The *Quarterly Return* of the Registrar General for the fourth quarter of 1960 gives the provisional figures for that year. Births, at 783,000, were 32,000 up on the previous year and 118,000 higher than in 1955, since when the figure has been steadily rising. The crude birth-rate at 17·1 per thousand was the highest since 1948, and the figures will present considerable problems for educational planners later in the 1960's. Infant mortality, at 21·7 per 1,000, is the lowest on record, and the nineteen-fifties have seen a fall in this index of one-third. Neo-natal mortality and peri-natal mortality have also fallen. The continued rise in births is an interesting phenomenon, and it will be necessary to await the detailed statistics to see whether the rise implies an increase in family size or merely a shift in timing. The population projections which are a feature of the *Quarterly Return* have been modified to take account of the rising number of births, and imply an increase in the population by 10 millions to 56 millions by the end of the century.

Water Research

Recent issues of the periodical published by the Water Research Association contain articles surveying two widely different subjects of interest to all concerned with the provision of public water supplies. It is well known that water supplies containing undue concentrations of nitrate are dangerous to infants because of a reaction between the nitrate and hæmoglobin in the blood. It is clear from the article in *Water Research News* (No. 10) that considerable research is required before the mechanism of this reaction can be fully understood. It does not appear likely that the nitrate can oxidize the hæmoglobin directly, and it is suggested that its effect is due to blocking of an enzyme system. No. 11 of *Water Research News* is devoted largely to a discussion of the mechanism of the coagulation process, which is of fundamental importance in the production of clear water supplies. In this case the article contains an account of the results of research work, and is primarily concerned with the effect of *p*H value on coagulation by aluminium sulphate; it is a summary of fuller technical papers on the subject.

The American Type Culture Collection

The American Type Culture Collection, Washington, D.C., has been given a grant of 865,500 dollars by the National Science Foundation towards the construction of a new building to house its collection of micro-organisms used in research and teaching. The Collection at present includes more than 5,000 strains of bacteria, yeasts, moulds, algae, protozoa and animal, plant and bacterial viruses. These materials, besides being of great importance for biological, medical, agricultural and industrial research and for training of personnel in the biological and medical sciences, also serve as standards for comparison with micro-organisms isolated from natural sources, and are employed for the assay and production of drugs, enzymes and other chemicals. During 1960, more than 12,000 cultures were distributed to various institutions. The new building, which, according to preliminary plans, will be of

about 30,000 sq. ft., will provide working space for about sixty people, including scientists, technicians, research assistants, etc. The estimated cost of the new building is 1,046,000 dollars. The Collection has received a grant of 90,278 dollars from the National Institutes of Health, and, in addition, about 150,000 dollars has been raised from private industry.

Co-operation between University and Industry in Manchester

THE Manchester Joint Research Council, established in 1944 as a co-operative effort between the University of Manchester and the Manchester Chamber of Commerce, now regards its most useful function as the extension of direct contact with local firms, particularly those small and medium-sized firms which depend on science and technology. As a basis for the necessary liaison work the Council has published two booklets. One of these is entitled *An Account of Some of the Scientific and Technological Facilities which Manchester University and the Manchester College of Science and Technology can offer to Industry*, and includes an indication of some of the research work carried out by the different departments (Pp. 19. Manchester: Manchester Joint Research Council, 1960). The other booklet is entitled *Sources of Scientific and Technical Information Available to Local Industry* (Pp. 21. Manchester: Manchester Joint Research Council, 1960). This appears to be less satisfactory than the first booklet: while there is a list of the research establishments of the Department of Scientific and Industrial Research, and of the Research Associations, and a list of some organizations which will name consultant experts in particular fields, publications are not covered, and under library services the only references are to the Manchester Technical Library and to Aslib.

Journal of Atherosclerosis Research

ATHEROSCLEROSIS is being studied nowadays by workers in a wide diversity of fields, and the results of their studies are appearing in many different journals. To try to co-ordinate publications on the disease, a new journal has been started (*J. Atherosclerosis Res.*, Elsevier, Amsterdam, bi-monthly, price £6 5*s*. a year). The editorial board contains members from more than a dozen countries, and the journal will contain review articles, research reports and short communications—usually in the English language. Communications on subjects related to atherosclerosis (for example, thrombosis) will also be accepted. The first part (January–February 1961) includes a review on morphological aspects of the disease by Prof. T. Crawford, and one on the thyroid and atherosclerosis by Dr. G. S. Boyd. Manuscripts may be sent to the editorial secretary, Dr. F. P. Woodford, Witte Singel 36, Leyden, The Netherlands, or to any member of the editorial board.

Life-History of the Green-veined Orchid

THE vast field of work for amateur naturalists is brought out by the continuous efforts of a schoolboy, J. F. H. Doulton, over the past three years, in the Report of the Rugby School Natural History Society for 1960 (Pp. 16. (94th issue). Rugby: George Over, Ltd., 1961). Doulton investigated the life-history of the green-veined orchid, *Orchis morio*. A quadrat was marked out, and, each year, all the plants of *O. morio* were marked on a map, together with a note of whether they were producing leaf or flowers. It is hoped to continue this work in the future to trace the life-histories of individual plants over a number of years, but it is already possible to draw tentative conclusions about the sequence of leaf and flower production. The general conclusions are that plants which have flowered do not do so again, at least in the first or second year after flowering; they are more likely to die after flowering than after being in leaf; their average life is four years; they are less likely to flower in their first year than in subsequent years. Several additional points must be taken into account when assessing these results. First, it is difficult in many cases to be sure that the investigator is following the same plant over several years because plants may come up in slightly different places, and the place of one plant may be taken by another. Secondly, there are five cases in which a plant has apparently remained dormant for a year; and it is possible that this behaviour may be more widespread, in which case some of the above conclusions may need modifying. Lastly, the observations refer only to plants producing conspicuous leaves or flowers and not to any previous year's growth as mycorhizome. Experiments on the removal of flower heads suggest that removal of flower heads before seed can be set makes it quite likely that the plant will flower again in the next two years.

Primitive Rock-Shelter Art in Australia

THERE is no doubt that interest in the Australian rock-shelter art is booming. Barely have notes on one publication been written before another is to hand. The *Journal of the Royal Society of Western Australia* (**43**, Pt. 4, 1961), among other articles, contains an account by P. E. Playford of rock paintings in the West Kimberley region of Western Australia. The article is illustrated with six full-page reproductions of the paintings. The local tribes know of the painted localities, but, while in some cases they tell stories about them, they say that they are the work of aborigines long ago. The paintings themselves include crude figures of animals and human beings, frogs, serpents, lizards, emus, crocodiles and kangaroos. The descriptive section of the article not only records localities but also attempts to explain some of the groups in terms of the myths obtained by questioning the local inhabitants. The article is one which will be welcomed by all students interested in this 'prehistoric' yet not very ancient rock-shelter art of Australia.

Termites and Coal Seams in Angola

IN England coal miners looking for outcrops often used to examine rabbit holes for signs of coal dust; a German firm of consulting engineers is seeking to assess Angola's resources in brown coal by studying the ant-hills built up by colonies of termites (*Science Afrique*, No. 22; October 1960). The theory is that termites prefer to build on lignite foundations and use the lignite as building material because its low-heat conductivity "keeps the house cool". They take the local light-coloured clay only as an outer covering to reflect away the heat of the sun. If the theory should prove to be sound, Angola with its countless termite hills may have big deposits of lignite. The nearest hard-coal mines are more than 500 miles away in Rhodesia, and locomotives on the country's railways still use wood as fuel. The assumption is that this might, with advantage, be replaced by briquettes made from brown coal.

Geology of British Borneo

An important monograph on *The Geology of Sarawak, Brunei and the Western Part of North Borneo* has recently been published by the Government Printer in Sarawak, sponsored by the Directorate of Overseas Geological Surveys. Since the discovery of the Miri oilfield in 1910, very large sums have been spent by the Royal Dutch Shell Group in geological explorations throughout British Borneo, culminating in an expenditure of close on £20 million in the decade 1949–58. The geology of the territories, no greater in size than England and Wales, is thus known in considerable detail. A Government Geological Survey was established in 1949, to which the reports of the oil companies were at once made available; and it is a reflexion of the happy relationships between Government and industry that this official monograph has been compiled by Dr. P. Liechti, of "Shell", in association with Dr. F. W. Roe and Dr. N. S. Haile, of the Geological Survey. The accompanying tectonic map (1:1,000,000) and geological maps (1:500,000) have been excellently colour-printed in the Netherlands. Congratulations are due to the authors, to their parent organizations, and to the Government Printer in Kuching for the production of a lucid description of a region of outstanding geological interest (Bulletin 3. Vol. 1 (Text): Pp. xvii + 360 + 73 plates. Vol. 2 (Portfolio). Table of Rock-Stratigraphic Columnar Sections. Tectonic Map. (Kuching, Sarawak: Government Printing Office; London: Overseas Geological Surveys.) 1960. 21 Malayan dollars: 49*s*. the two volumes).

Beit Memorial Fellowships

The Trustees of the Beit Memorial Fellowships for Medical Research, in their report, announce that Prof. Alexander Haddow has been elected a member of the Advisory Board. The following elections have also been made: *Junior Fellowships*, to S. P. R. Rose, to investigate the properties and localization of certain enzymes associated with the active transport of ions across cellular membranes in nervous tissue, at the Department of Biochemistry, University of Oxford; Dr. R. Laverty, to investigate the action of drugs on catechol-amines in the central and sympathetic nervous systems, at the Agricultural Research Council's Institute for Animal Physiology, Babraham; Dr. Ruth F. Itzhaki, to investigate the radiosensitivity of deoxyribonucleoprotein under various conditions with the view of explaining the action of radiation on malignant tissues, at the Department of Radiotherapeutics, University of Cambridge; C. W. F. McClare, to investigate energy transfer in nucleic acids, at the Department of Radiotherapeutics, University of Cambridge; S. S. Hayreh, to investigate experimentally the pathogenesis of papilloedema, at the Institute of Ophthalmology, London. *Fourth-year Fellowship*, to Margarethe M. A. Holzbauer-Sharman, to enable her to continue investigations into the mechanisms involved in the increase in the secretion of aldosterone following haemorrhage.

American Academy of Arts and Sciences: Grants-in-aid

Grants-in-aid, ranging between 500 dollars and 1,500 dollars, are available from funds administered by the American Academy of Arts and Sciences for research in any recognized scientific field, including mathematics, physics, biology and the social sciences. Applications must be received before September 1 for grants to be made in October. In general, applications from individual scientists rather than from institutions are favoured, although this is not an inflexible policy. Support is not usually given for work aimed primarily at fulfilling the requirements of an academic degree. Further information and application forms can be obtained from the American Academy of Arts and Sciences, Committees on Research Funds, 280 Newton Street, Brookline Station 46, Boston, Mass.

Lederle Medical Faculty Awards

The Lederle Laboratories Division of the American Cyanamid Company is making available a number of medical faculty awards which will begin with the academic year 1962–63. These awards are intended only for individuals who share in all departmental responsibilities, particularly in the teaching of undergraduate medical students. They are not intended to be research fellowships, or for the support of individuals whose only or major function and interest is in the conduct or supervision of research activities. Also, these awards are not intended for assistance of research departments or divisions of postgraduate medical schools. The awards are primarily intended to assist medical schools in providing for their major clinical disciplines individuals who, having demonstrated ability and interest in teaching and research, will devote their major efforts to the teaching of clinical medicine with the view of integrating the knowledge and principles of the biological sciences, as applied to man. Further information can be obtained from the Lederle Medical Faculty Awards, Office of the Secretary, Pearl River, New York.

Graduate Course in Electrical Machines

The University of Birmingham is organizing a graduate course, lasting twelve months as from October 1, on "Electrical Machines". The course is available to honours graduates in electrical engineering who have, preferably, had a year or two of engineering experience outside the university. The syllabus for the course consists of five major sections: (1) electromechanical energy conversion; (2) analysis of rotating machines; (3) mathematical techniques; (4) either electrical properties of materials, or electronic computers (analogue and digital); (5) automatic control systems. The fee for this course will be £81. Further information can be obtained from the Graduate Course Supervisor, Electrical Engineering Department, the University, Edgbaston, Birmingham 15.

The Tenth International Botanical Congress, Edinburgh, 1964

At a meeting of the ninth International Botanical Congress in Montreal in 1959 it was suggested that the tenth Congress might be held in the United Kingdom in 1964. On the recommendation of the British National Committee for Biology, the Royal Society of London on behalf of all host organizations suggested that the tenth International Botanical Congress should be held in Edinburgh during August 3–12, 1964. Representatives were invited from universities, research institutes and biological societies to a meeting in the Senate Hall of the Old College, Edinburgh, on March 22, 1961. Prof. H. Godwin, of the University of Cambridge, has been elected president of the Congress. Joint secretaries of the Executive Committee, which is to be concerned with

the preparation and planning of the Congress, will be Prof. G. E. Fogg, Department of Botany, Westfield College, Hampstead, London, N.W.3, and Dr. A. J. Brook, Department of Botany, University of Edinburgh, at the Royal Botanic Garden, Edinburgh 3.

The Night Sky in June

New moon occurs on June 13d. 05h. 17m. U.T. and full moon on June 28d. 12h. 38m. The following conjunctions with the Moon take place: June 2d. 18h., Saturn 3° S.; June 3d. 06h., Jupiter 3° S.; June 9d. 09h., Venus 2° N.; June 18d. 10h., Mars 2° N.; June 18d. 20h., Regulus 0·5° N.; June 30d. 00h. Saturn 3° S.; June 30d. 12h., Jupiter 3° S. In addition to these conjunctions with the Moon, Mars is in conjunction with Regulus on June 27d. 08h., Mars being 0·7° N. Mercury is an evening star, visible during the first few days of the month low in the west after sunset; later in the month it is too close to the Sun for observation. Venus is a morning star, rising at 2h. 15m., 1h. 50m. and 1h. 25m., on June 1, 15 and 30, respectively. Its stellar magnitude on June 15 is −4·0; the visible portion of the apparent disk increases from 0·379 to 0·555 during the month, and its distance from the Earth increases from 51 to 73 million miles. Mars is an evening star, but conditions for observation are becoming less favourable. It sets at 23h. 30m. on June 15. Jupiter rises at 23h. 40m., 22h. 45m. and 21h. 40m. on June 1, 15 and 30, respectively. It is in Capricornus; its stellar magnitude on June 15 is −2·2 and its distance from the Earth on that date is 400 million miles. Saturn rises at 23h. 20m., 22h. 20m. and 21h. 15m. at the beginning, middle and end of the month, respectively. It is near the border of Sagittarius and Capricornus; its stellar magnitude on June 15 is + 0·5 and its distance from the Earth is 850 million miles. There is one occultation of a star brighter than magnitude 6 visible at Greenwich: June 3d. 1h. 42·2m., ρ Cap, reappearance. The summer solstice occurs on June 21d. 16h.

Announcements

Mr. M. J. Lighthill, director of the Royal Aircraft Establishment, Farnborough, has been awarded the Hopkins Prize of the Cambridge Philosophical Society for his contributions to fluid mechanics. The Prize has been awarded every three years since 1867 for work in mathematical-physical or related fields; the present award relates to the period 1957–60 and is of the value of £200.

Mr. Charles A. Marshall, editor of *British Communications and Electronics*, has been appointed honorary secretary of the Television Society in succession to Mr. Geoffrey Parr, who has been elected to an honorary life fellowship of the Society in recognition of his services during the past fifteen years. Mr. Parr will continue to edit the Society's *Journal*.

A summer school in quantum chemistry is being organized by Prof. C. A. Coulson and the Delegacy for Extra-mural Studies at St. Antony's College, University of Oxford, during September 9–23. Further information can be obtained from the Secretary, Extra-mural Delegacy, Rawley House, Wellington Square, Oxford.

The Institution of Engineering Inspection and the Society of Non-Destructive Examination are jointly organizing a conference at Oxford during September 5–8. Further information can be obtained from the Oxford Conference Secretariat, Institution of Engineering Inspection, 616 Grand Buildings, Trafalgar Square, London, W.C.2.

A conference is to be organized jointly by the University of Southampton and the Timber Development Association on "Timber Engineering", at the University of Southampton, during September 18–23. Further information can be obtained from Dr. H. G. Allen, Department of Civil Engineering, University of Southampton.

A symposium on North Atlantic biota and their history is being arranged under the sponsorship of the NATO Advanced Study Institutes Programme and will be held in Reykjavik during the first two weeks of August. Further information can be obtained from Dr. Áskell Löve, Institut Botanique de l'Université de Montréal, 4101 est, rue Sherbrooke, Montreal.

The Netherlands University Foundation for International Co-operation is organizing a summer school in science, which will be devoted to "Fundamental Problems in Statistical Mechanics", at Breukelen, The Netherlands, during August 1–16. Further information can be obtained from the Registrar, Netherlands University Foundation for International Co-operation, 27 Molenstraat, The Hague, The Netherlands.

A symposium on "Photomultiplier Tube Applications" is to be held at E.M.I. House, Manchester Square, London, W.1, during September 13–15. The symposium is being organized for the exchange of information on the application of photomultiplier tubes in a wide variety of scientific and industrial fields by E.M.I. Electronics, Ltd. A small nominal fee will be charged. Further information can be obtained from Mr. B. Johnson, Press Officer, E.M.I. Electronics, Ltd., Hayes, Middlesex.

A new series of publications, the *Annual Review of Astronomy and Astrophysics*, is being arranged by Annual Reviews, Inc., Palo Alto, California. The first volume will appear in the autumn of 1963, under the editorship of Dr. Leo Goldberg, Higgins professor of astronomy, Harvard University.

Translations into English of the Russian optics and spectroscopy journal, *Optika i Spektroskopiya*, have been arranged by the Optical Society of America. Special terms have been arranged for societies wishing to join the translation scheme and non-members and libraries. Further information can be obtained from the Assistant Secretary, OSA, 1155 16th Street, N.W., Washington 6, D.C.

Vol. 4, Part 5, of Scientific Institutions and Scientists in Latin America, issued by the United Nations Educational, Scientific and Cultural Organization, Montevideo, contains information received during the printing of the three former volumes, to which it is an appendix (Pp. i + 707–767. Montevideo: Unesco; Centro de Co-operacion cientifica para America Latina, 1960).

Hilger and Watts, Ltd., announce that Wray (Optical Works), Ltd., have come into association with them. Mr. A. W. Smith, a former president of the Scientific Instrument Manufacturers' Association, and chairman of its Education Committee, is continuing as managing director of Wray (Optical Works), Ltd.

MAN AND THE SOIL

A SYMPOSIUM, arranged jointly by the London Branches of the Institute of Biology, the Royal Institute of Chemistry, and the Institute of Physics and the Physical Society, was held on March 15 at the Senate House, University of London. The general title was "The Soil: Problems raised by its Use and Misuse", and the seven main speakers dealt with this question from the different points of view of biologists, chemists and physicists. Often a meeting of this kind, no matter how carefully planned, becomes in effect a series of unrelated papers. On this occasion the different contributions were clearly interrelated, and each contributed much to the understanding of the others.

The first speaker was Sir John Russell, who spoke on "Soil as Nature left it—Man's Use and Misuse". Sir John has, in an active working life as a soil scientist of more than sixty years, contributed more to our knowledge of the soil than any other person. He has always taken a broad view of the subject, and although he started as a chemist much of his work has elucidated problems of soil biology. On this occasion his paper did much to draw together the themes of the subsequent speakers. He showed how the equilibrium of a natural soil is upset by cultivation, and how a new equilibrium may be reached. Man may destroy the soil, but he may also prevent this destruction. Perhaps the most serious problem facing mankind to-day is whether research will be continued and applied in under-developed countries, now self-governing, so that the fertility of their soils can be maintained.

Mr. E. Crompton next spoke on "Soil Formation". He described the five soil-forming factors—parent material, climate, organisms, relief and time—and described how they combine to condition certain physical, chemical and biological processes occurring in the soil itself. The processes, which are the immediate mechanisms producing profile differentiation, he summarized as erosion/deposition, weathering, translocation and the organic cycle. These processes may produce many combinations, reflecting the geographical variety of the soil-forming factors.

"Physical Properties of Soil" was the title of the paper by Dr. H. L. Penman. He showed that soil physics has three aspects, for the emphasis of a technical problem may fall on the soil as a particulate system, as a porous system, or as a quasi-homogeneous system. Particle problems arise in weathering of soil, in clay mineralogy, in studies of soil structure. Pore-space problems are very important, for the biotic part of the soil needs living space, with water laid on, and some degree of air conditioning. In thermal studies, soil may be treated as homogeneous. However, ultimate explanations must go back to a study of particle properties, pore properties or both together.

Dr. G. W. Cooke spoke on "Some Chemical Aspects of Soil Fertility and Crop Production". He defined 'soil fertility' as the capacity of a soil to produce the crop desired. Fertility is not absolute, for a soil fertile enough to support a good forest may be so poor that farm crops fail on it. The term 'fertility' integrates physical and chemical factors that influence supplies of water, air and nutrients to roots; in addition, a fertile soil must anchor plants satisfactorily and be easy to cultivate and penetrate by roots. Chemical aspects of fertility are concerned mainly with nutrient supplies and reserves, but they also involve physical factors that affect root growth and penetration. The essential nutrients obtained from soil are calcium, potassium, magnesium, nitrogen, phosphorus and sulphur (the major nutrients) required in quantities of pounds or hundredweights per acre, and the much smaller quantities of micro-nutrients (from a few grams to a few ounces per acre are needed) boron, chlorine, cobalt, copper, iron, manganese, molybdenum and zinc. The rational use of different chemical fertilizers was indicated, and the importance of available or non-available reserves was discussed. Chemical analysis of soils, and the relation of the results to agriculture, is still a subject requiring much research.

The first primarily biological paper was on "The Interaction of Agricultural Practice and the Soil Fauna", by Dr. K. Mellanby. He stressed our ignorance of the soil fauna, and the difficulties in studying it. No complete census of the soil fauna of any field exists. Where soil animals are pests and destroy crops, these forms have been more thoroughly studied, and successful control measures devised, but the effects of these control measures on the rest of the fauna are unknown. Soil animals are believed to affect soil structure, the breakdown of organic matter and its incorporation in the soil, but few accurate quantitative data exist. Even earthworms, which often form more than 50 per cent of the total weight of the soil fauna, are animals the biology of which we still do not understand.

Dr. S. D. Garrett spoke on "Farming Patterns and Soil-borne Diseases of Crops". Crop rotation has, for centuries, been the main method of controlling soil-borne disease, as well as of controlling many insect pests and weeds. The efficacy of crop rotation depends on the host specialization of most parasites. Unfortunately many soil-borne diseases are caused by fungi with long-lived resting bodies, and so complete control requires rotations of undue length. 'Decoy crops' and other methods may eliminate some of the resting spores. Crop rotation alone cannot often eliminate a pest, but may keep parasite populations down to an acceptable level. Modifications of crop husbandry can prevent parasites from causing serious crop losses.

The last paper, by Mr. G. V. Jacks, was on "Climate and Erosion". He showed that four main factors determine the amount of man-accelerated soil erosion. These are land utilization, relief, erodibility of the soil, and the intensity of rain or force of wind. Land utilization is the only one of these factors controlled by man; it is also the most important, for natural erosion is generally important only in regions so arid that few crops could be grown. The importance of devising means of maintaining a complete plant cover in seasons when rain or wind would be likely to cause erosion was stressed. When this is done, the danger of erosion can be greatly decreased, and fertility restored in land already seriously affected by erosion.

KENNETH MELLANBY

SOLAR SEEING

WHILE the role of the atmosphere in degrading optical images has received considerable attention in respect of night-time observations, the question of day-time seeing has been almost completely ignored. In both cases temperature inhomogeneities cause the damage, though diurnal heating of the lower atmosphere results in conditions much worse by day than by night. Largely with the aim of stimulating interest in a subject of extreme importance to the selection of solar observatory sites and the design of solar telescopes, the Consiglio Nazionale delle Ricerche, with the co-operation of the Rassegna Internazionale Elettronica e Nucleare, organized a small symposium on "Solar Seeing" in Rome, during February 20–25.

In his opening address, Prof. M. G. J. Minnaert (Astronomical Observatory, Utrecht) differentiated between the blurring, dancing and scintillation (or intensity variation) of stellar images, and reviewed measurements of them. In general, there is little correlation between scintillation and blurring because the former results from the focusing effect of distant inhomogeneities only, whereas blurring and dancing can originate anywhere in the light path. The very few observations of stellar scintillation in the day-time have suggested that this is at most a factor of 1·5–2 stronger than at night, confirming its origin in the high atmosphere where changes due to diurnal heating are relatively small. Prof. Minnaert referred to the waviness of the limb on the solar image, pointing out that if the disturbed atmospheric layer is localized and if the direction of wave motion is parallel to the wind, a combination of the apparent velocity along the limb with that of shadows on the objective seen through a focal plane slit can give the layer height and velocity. As the subsequent controversial discussion demonstrated, a clear description of the phenomenon of limb waviness is as yet lacking, and its causes are still uncertain.

Prof. K. O. Kiepenheuer (Fraunhofer Institute, Freiburg) described seeing conditions at a wide number of sites in Europe. Wendelstein (1,840 m.), the highest mountain peak in its neighbourhood, has the best seeing conditions known in Germany, particularly with high-pressure systems, low wind velocities and snow-covered ground; but the total amount of sunshine is small. At Kanzelhöhe (1,560 m. and 1,900 m.), on a mountain covered with green woods, seeing is good only for a brief period in the morning, and possibly late afternoon, though it remains good longer at the greater height. Here, too, seeing is better in high-pressure conditions. At Zugspitze (3,000 m.), the seeing is good unless the wind is too strong. Freiburg, in the Rhine Valley, and Schauinsland (1,200 m.), nearby in the Black Forest, can differ greatly in seeing, but not preferentially. With easterly winds, seeing is bad presumably because the trees cause turbulence, while with westerly winds a turbulent 'Fern wind' descends from the Vosges mountains, causing bad seeing. However, very good seeing is again associated with high-pressure systems. At Lake Locarno (500 m.), the seeing improves continuously until early afternoon, being best when there is a general westerly wind, the nearby mountains funnelling it northwards over the Lake towards the observatory. Conditions deteriorate as the wind stops. At Anacapri (160 m.), seeing is good only in the morning and with winds from the sea, lasting longer in winter than in summer. With off-shore winds from the Apennine Mountains, seeing conditions are bad. In summary, Prof Kiepenheuer stated that sea breezes bring good seeing, siroccos bring bad seeing. In general, high-pressure systems are superior to low-pressure systems, presumably because with the former there is air slowly descending, while with the latter there is ascending air which has moved in over the heated ground. During summer, an increase of 10 m. in the height of the observatory above the ground can bring 2–3 more hours of good seeing.

Dr. G. E. Moreton (Lockheed Solar Observatory, Burbank), too, reported general correlations of seeing with meteorological conditions at the Lockheed Observatory. The Observatory (500 m.), open overhead and having a wooden floor with gaps, overhangs a hill and catches up-slope breezes. Definition is generally good with low inversion layers and poor with high inversion layers. At the Pic-du-Midi, Dr. J. Rösch (Observatoire du Pic-du-Midi, Bagnères-de-Bigorre) has found that good definition, though possibly with a little distortion, holds for an hour or so after sunrise. It is interesting that the time of optimum seeing differs for different instruments, clearly depending on the onset of turbulence associated with quite local heating. Miss Torelli (Rome Observatory) outlined observations of seeing conditions which indicate that in Rome image blurring is least in summer, though on the contrary the waviness of the limb is least in spring, late autumn and early winter. Finally, Dr. R. G. Giovanelli (Commonwealth Scientific and Industrial Research Organization, Sydney) described results obtained by Dr. Bray and Mr. Loughhead near Sydney. Recording limb-unsteadiness photoelectrically, they have found that on a day of good seeing there may be 50–200 occasions of good definition, each lasting a few seconds. In these, the limb steadiness first improves very rapidly (in a few seconds or even less than a second), and afterwards deteriorates to a more average value equally quickly; Dr. Priestley had suggested that this might possibly be correlated with a similar intermittancy in temperature fluctuations in the lower atmosphere, due to convective plumes, the rising air in which shows inhomogeneities of the order of 1 deg. C., the air between the plumes being uniform to better than 0·1 deg. C.

The design of solar telescopes to avoid internal seeing problems has interested a number of astronomers in recent years. Distinction may be made between long focal-length telescopes and short focal-length instruments where there is strong heating near the prime focus. In both cases, however, the height above the ground is important. Prof. D. H. Menzel (Harvard College Observatory) described the precautions being taken at the National Observatory, Kitt Peak, by water-jacketing the tower telescope so as to obtain homogeneous air in the long light-path within the instrument. As an aid to deciding the height of the tower, preliminary observations had been made on the temperature fluctuations at various

heights in the atmosphere. Typically ΔT was approximately 2–3 deg. C. a foot or so above the ground, 1 deg. at 10 ft., 0·2 deg. at 55 ft. and 0·1 deg. at 180 ft., with a resolving time of about 1 sec., these results according with those of various micrometeorologists. A few preliminary observations made in Sydney of deviations produced in horizontal light beams at various heights were described by Dr. Giovanelli, the root mean square deviations falling off exponentially in the first 20 ft. with a scale-height of about 11 ft. These scanty results had been used to fix the height of the axis of the 5-in. equatorial photoheliograph at 9 ft. Mounted in the open, the use of air suction devices near all surfaces of this instrument exposed to direct sunlight, including the prime focus, seems to have eliminated completely any air inhomogeneities in or immediately outside the telescope.

Prof. Kiepenheuer showed a model of a new photoheliograph, to be made by Zeiss (Oberkochen), with the objective 10–14 m. from the ground. This instrument is also to be mounted in the open, but a special feature is a completely separate wind shield surrounding the telescope tube. To reduce heating, the supporting tower is to be faced with white tile, the heat reflectance of which is reputedly extremely high. A rather different approach to telescope design is the new Pic-du-Midi instrument, where Dr. J. Rösch has the telescope tube projecting well through the slit of a dome, the slit being sealed to prevent the mixing of internal and external air. Whatever be the relative merits of these various schemes, it is clear that, by bold but careful planning, considerable progress has been made in reducing or eliminating internal seeing problems. Moreover, it was welcome to hear from Prof. Menzel that proper thermal insulation of the large Sacramento Peak spectrograph had enabled it to yield definition as good as that of the vacuum spectrograph.

Whatever improvements are made, ground-based observations will almost certainly remain limited by atmospheric seeing conditions. Two devices to assist in the best use of moments of excellent seeing are the seeing monitor, which automatically selects these instants, and the electronic camera, which enables exposure times to be reduced so as to use them best. In Sydney, a seeing monitor operating on the steadiness of the solar limb has been used successfully by Dr. Bray and Mr. Loughhead to obtain, among other things, sequences of observations of facular granules; while a second device developed by Dr. Ramsay and Mr. Kobler is ready for field trials on stellar images, and with slight modification can be used for deciding movements of greatest granule contrast. Dr. Rösch has been experimenting with a somewhat similar device, recording the intensity fluctuations as a pinhole is scanned rapidly across the solar image; even at the best of times, successive scans show significant differences due to seeing.

Photographs have been obtained by Prof. G. Wlerick (Observatoire de Meudon, Paris) and Dr. Rösch and Mlle. Dupré on nuclear emulsions with a Lallemand electronic camera. The great speed (approximately 100 times that of normal photography) has already been used to obtain improved photographs of double stars and planets, while high-resolution solar spectra have been photographed in less than 0·1 sec. There is little doubt that, combined with a seeing monitor, the electronic camera will yield spectra showing the full angular resolution of the telescope.

A group of papers on meteorological aspects of turbulence left one with the feeling that the association between solar seeing and turbulence has been given much too little attention; the field is wide open for exploration. This was the general feeling of participants also, who at the final session passed the following resolution: "The members of the symposium are convinced of the necessity for more extensive research on seeing problems, particularly with the view of application to the selection of observatory sites; and therefore recommend that basic studies be made of the optical properties of the atmosphere".

R. G. Giovanelli

TROPICAL ECOLOGY IN INDIA

A SYMPOSIUM on "Ecological Problems in the Tropics" was held at Allahabad during February 3–5, under the auspices of the National Academy of Sciences (India). The meetings were attended by more than one hundred scientists from all parts of the country. Dr. M. S. Randhawa, vice-president of the Indian Council of Agricultural Research, New Delhi, inaugurated the symposium and in his opening address specifically stressed the importance of ecological research in various development projects that the Government of India has taken in hand for the proper survey, development and exploitation of natural plant wealth of the country and for the increase in the production of food, fodder, fuel and fertilizers.

Dr. G. S. Puri, director of the Central Botanical Laboratory, Allahabad, who had organized the symposium, pointed out the progress so far made in Indian ecology and the need for a co-ordinated research programme in ecological studies in the tropics. He emphasized that the vegetation and animal life in the tropics raised problems entirely peculiar to these climatic conditions. He explained the concept of the forest ecosystem and recommended the use of *The Forest Ecosystem Proforma* published by the International Society for Tropical Ecology for use by the scientists in ecological studies and the application of the data to agriculture, forestry, soil and water conservation, desert immobilization, flood control, land use planning and wild life conservation, etc.

Forty-five papers were contributed to the symposium.

The paper by Sir Harry Champion on tropical ecological problems and by J. H. Davis were discussed with a number of those present. Prof. N. R. Dhar spoke on the value of nitrogen and phosphorus in Indian soils. Interesting papers were presented on the following subjects: tropical soils by Dr. G. S. Puri and K. Lakshminarayanan; fish ecology by Dr. S. M. Das and D. B. Saxena; arid zones by Sri S. K. Jain; relationships between habitat conditions and genome by Dr. R. P. Patil; distribution of perennial plants by Dr. J. K. Choudhury; soils of Madhya Pradesh by Dr. S. C. Pandeya; grasslands by Dr. S. S. Ramam; mangroves by Sri S. S. Sidhu; ecological problems in

the Western Himalayas by Sri M. K. Wali; *Aspergilli* by Dr. B. S. Mehrotra; humid tropics by B. S. Ahuja and K. P. Singh; sal leaf litter by Sri N. K. Jain.

At the end of the symposium the following recommendations were made:

"Ecologists working on the tropical region, particularly Indian ecologists, should undertake co-operative studies to fill up the lacunæ in our knowledge as soon as possible. For achieving the purpose it is desirable to launch a vigorous and intensive programme of research with a view to obtaining data of practical and immediate applicability to agriculture, forestry and soil, water and wild life conservation. It is felt that *The Forest Ecosystem Proforma* prepared and published by the International Society for Tropical Ecology will be found of extensive utility. The same with a suitable amendment can be conveniently used for studies of animal and human ecology."

A committee to implement and expand the results of the symposium and to raise necessary funds needed for supporting the project in co-operation with the International Society for Tropical Ecology was formed. Further information concerning this project can be obtained from Dr. G. S. Puri, general secretary, International Society for Tropical Ecology, 10 Chatham Lines, Allahabad. *The Forest Ecosystem Proforma* can be obtained from the Society, price Rs. 5.

THE WEST AFRICAN RICE RESEARCH STATION

THE West African Rice Research Station, which is situated at Rokupr in Sierra Leone, is supported by the four West African territories of Nigeria, Ghana, Sierra Leone and Gambia. It is now ten years since a free grant from the United Kingdom under the Colonial Development and Welfare Act enabled the existing experimental station of the Sierra Leone Department of Agriculture to be transformed into a major inter-territorial research station, and five years since completion of buildings and establishment enabled a full-scale research programme to be started. It is hoped that this year will mark a further stage in development and that the Station will attain the status of an independent institute.

Rice production and consumption is expanding rapidly in West Africa, not only in Sierra Leone and adjacent parts where it has long been the staple food of the population but also in all other territories where it is of more recent cultivation. Present production in the whole of West Africa is estimated to be about one and a half million tons of paddy per annum, of which just more than a quarter of a million tons is produced in Sierra Leone. In view of the important part that rice seems destined to play in the economy of West Africa as a major food crop and in efficient utilization of the land, all Governments gave support to the establishment of the Station, the basic policy of which is to carry out fundamental research on rice as a crop under West African conditions, and to advise territorial Ministries, who remain responsible for local application and extension work, on their programmes of rice development and production.

The main station at Rokupr, in addition to an area of upland for administrative, laboratory and farm buildings and staff quarters and for experimental work on upland rices, consists of a 66-acre swamp rice-farm contiguous with the estuary of the Great Scarcies River, from which it is irrigated by tidal flooding with fresh water throughout the growing season. In addition, the Station maintains small areas on other types of soil in different parts of Sierra Leone. The laboratories, which were built in 1955, are well equipped and have recently been supplemented by a series of cabinets with controlled illumination and temperature for work on growth, an open-sided greenhouse for pot-work with soils and culture media, and a deep-water tank for experimental work with floating and flood-resistant rices. An air-conditioned building is provided for storage of the seed of the West African varietal collection, which is maintained by the Station, the responsibilities of which also include the maintenance of nucleus pure seed stocks of established and recommended varieties for seed multiplication schemes of the contributing territories.

At present the cultivation of rice in West Africa is carried out under a wide range of natural water conditions, from those of coastal mangrove swamps to the seasonal flooding of riverain plains in the lower-rainfall areas. There are extensive and widespread areas, potentially useful for rice growing, at present undeveloped. The attention of the Station has thus been concentrated on the investigation of the rice plant in relation to its habitat and on the production of rice varieties to suit natural conditions, together with work on soils and the changes that occur in them when modification of conditions may take place during development.

Selection from local and introduced varieties of rice has given excellent results in the improvement of yields in the past, but the stage has been reached when further advances can only result from a breeding programme which includes hybridization. The primary object of the present programme is the provision of high-yielding acceptable rice varieties for all the major West African habitats, including deep-flooding areas and rain-fed uplands. While consideration is given to factors such as disease-resistance, straw-strength and milling quality, none of these at present is of such importance as to warrant specific breeding programmes, and they are considered merely as they reflect on yield. Recent series of trials in various parts of West Africa indicate, however, that in some areas effects of light and, possibly, temperature are limiting in preventing existing established varieties from attaining their full potential, and a specific breeding programme for early maturing varieties insensitive to photoperiod is being undertaken. In conjunction, physiological investigations have been started on the effects of light and temperature on duration and yield.

Other physiological work to date has been largely designed to produce useful techniques for the plant breeders. Work on viability and dormancy has resulted in improved storage of seed and speeding up the breeding programme, while investigations into hydroponics and culture media have led to a method of clonal multiplication of considerable value in experimental use. Work on milling quality—in particular with the use of parboiling, the recommended and accepted method in West Africa—has indicated

that modifications in established milling practice would probably increase the efficiency and output of the commercial mills to an appreciable extent.

Research on soils has been concentrated, during the past few years, on the chemistry and microbiology of mangrove soils; in particular, on the problems of their reclamation in areas where flood-waters are saline throughout the year. These soils, which are paralleled by vast areas of similar soils in many parts of the world, pose particular problems due to their high content of sulphur and their potentiality for acid-development by microbial action on drying. Research work has now led to an understanding of the processes occurring in these soils and to the formulation of techniques of reclamation which are at present being tested in the field. More recently, attention has been paid to the changes in nutrient status of these soils—which are potentially highly fertile in their natural state—when they are reclaimed and cultivated.

Investigations are now being made into the relationship between the rice plant and soil conditions, in particular the oxidizing or reducing status of the soil and its poising by the balance of ferrous and ferric iron present. It is considered that this investigation will lead to useful techniques in the initial testing of soils for their suitability for rice growing, and for predicting the effect on them of specific modification of natural conditions.

Contributing Governments are kept informed of immediate practical recommendations, and an annual report of world-wide distribution is published to record briefly the work in progress; individual researches are reported more fully by contributions to technical journals. It is of note that within ten years of its inception the Station has been able not only to play its part in the general economic development of West Africa but also to contribute substantially to scientific knowledge of the world's major food crop.

H. D. Jordan

TECHNICAL EDUCATION IN WALES

A RECENT report dealing with technical education in Wales* is as surprising for the boldness of its recommendations for training within industry as it is for its ambivalence about the resolution of educational and administrative problems within its purview. Within a brief sixty pages it first reviews the history of technical education in Wales with candid admissions of former shortcomings, then it surveys the great changes in industrial background. The present pattern of technical education is next reviewed, under three main headings, of courses and training for craft apprentices, student apprentices and graduate apprentices. Significant differences are noted from the rest of the British scene. In this way the report rapidly traverses the background to its terms of reference, which were "In the light of contemporary changes in the industrial pattern in Wales, to consider what educational provisions should be made to serve the best interests of industry and of those employed in it."

The fourth and final chapter of the report of the Central Advisory Council for Education (Wales) embodies the Council's observations and recommendations, some of which go well beyond the particular needs and circumstances of Wales. The report incorporates much contemporary discussion and exhortation, and thus joins in the now customary commendation of such developments as block-release courses, sandwich courses, pre-apprenticeship courses, group apprenticeship training schemes, a two-year Ordinary National Certificate course, the introduction of lower standard courses for new City and Guilds of London Institute examinations, and other ideas to be found in the Crowther Report and the second White Paper *Better Opportunities in Technical Education*.

A fundamentally new approach for industrial training in the United Kingdom is urged in the proposed establishment of a national craft apprenticeship system, especially to meet the needs of small firms which largely compose British industry, particularly in Wales. This would be administered by the State through the Ministry of Education and a National Apprenticeship Council, training being given from the age of sixteen years in apprentice training centres. The centres may or may not be attached to technical colleges, and would be financed by an apprenticeship levy on industry (though curiously this important point is not mentioned in the final summary of recommendations). This proposal constitutes a strong challenge to present Government policy, and to the existing Industrial Training Council; but the report sees no other adequate way of meeting the compelling needs of the greatly increased age-groups 16–19 years coming into industry from 1963 onwards, or of meeting the needs of smaller firms.

With regard to advanced courses, the report concludes that the overall provision greatly outruns the present demand, and urges that to avoid wasteful and inefficient duplication these courses should be confined to five technical colleges—Treforest, Newport, Swansea, Wrexham, *together with* the Welsh College of Advanced Technology in Cardiff. The words here shown in italics illustrate the Council's refusal to grasp the essential ideas of the four-tier structure of technical education, with preferential concentration of advanced courses in the colleges of advanced technology. This is related to its somewhat despairing view of the continued existence of the Cardiff College, of which it presents a very partial picture indeed (it has 186 in sandwich courses within four years of its designation out of a total sandwich course *and* full-time enrolment—not mentioned—of 826 students—compared with 732 students at the University College of North Staffordshire after 10 years of existence, not to mention the former's large part-time enrolment).

The report suggests that all five colleges should be administered jointly by an administrative council which might be the technical sub-committee of the Welsh Joint Education Committee. Never was there a better example of the new Benthamism—the greatest pacification of the greatest number of local education authorities, and consequently, the strongest possible built-in deterrent to the emergence of concentrated excellence at the College of Advanced Technology. Not surprisingly, the Council concludes

* Ministry of Education: Central Advisory Council for Education (Wales). *Technical Education in Wales*. Pp. ix + 146. (In English and Welsh.) (London: H.M. Stationery Office, 1961.) 7s. net.

that the proposal to seek closer association of the latter college with the University is not inconsistent with the purposes of the University. So little does it regard the Welsh Adv. nced College in its own right, that it sees the link with the University as unquestionably conferring status on technical studies in Wales, and that "A further and quite substantial advantage would be that a clearer and more easily recognisable line of demarcation than now exists could be drawn between the College of Advanced Technology and other technical colleges concerned with advanced courses". Under the Administrative Council, or under University governance, or both? What happens then to the new route in higher education complementary to that of the universities, and to the apex of the technical college system?

Instead of being doubled in size through bilingual publication, the report would have been better had it analysed more fully the consequences of its recommendations, and also dealt with some important omissions. Notable among the latter are some of the basic reasons why less than 2 per cent of eligible Ordinary National Certificate candidates go on to courses for the Diploma in Technology, and less than 7 per cent to Higher National Diploma courses. Do the other colleges accept a contributory role to the higher colleges? The resistance to change and support of new ventures, for example, by the schools and firms, are hinted at but not fully examined. Nowhere does the report deal candidly with the issues underlying "the delicate work of regionalisation of advanced courses . . ." which as an independent body it ought to have done; it is not surprising already to find it reported that the Flintshire authorities are taking steps to protect their right to advanced courses. A more penetrating and critical examination on the educational and administrative sides, as was done on the apprenticeship side, would have greatly increased the value of the report. The Minister of Education commends the report as a good one, and hopes that many of the recommendations will be put into practice as soon as possible; many, it may reasonably be hoped, but not some of its major ones, not at all before due consideration has been given to the report of the Committee of Enquiry into Higher Education, of which Lord Robbins is chairman.

P. F. R. Venables

ADDICTION-PRODUCING DRUGS

In the eleventh report issued by the World Health Organization's Expert Committee on Addiction-producing Drugs* recommendations are given that the following substances should be subject to the provisions of the 1931 Convention in respect of addiction-producing drugs comparable to morphine: clonitazene, diapromide, diphenoxylate, etonitazene, hydromophinal, phenampromide and phenoperidine.

Evidence concerned with two analgesic benzodioxane derivatives and ethoheptazine indicated that these compounds were not to be regarded as addiction-producing drugs. Exemption from the provisions of international control was recommended in favour of two preparations containing diphenoxylate, a new constipating agent, but the Committee was unable to support the request for exemption in favour of dextro-phenomorphan.

The Committee was concerned with reports on the abuse of amphetamines and amphetamine-like substances contained in weight-reducing medicines, and emphasized the need for appropriate control measures on a national level to prevent such abuse. Attention was also directed to the need to watch closely the development of new psychically active compounds that might be abused by narcotic addicts, as has already occurred in the case of SPA((−)-1-dimethylamino-1,2-diphenylethane) in Japan. There is need for improvement in regard to the information given on the possibilities of addiction liability of new drugs, particularly where analgesic and anti-cough properties are claimed.

In response to an invitation from the Economic and Social Council, the Committee outlined the procedure by which the addiction-producing properties of a drug are established; but a precise code of practices cannot be drawn up at the present time.

The Committee was not of the opinion that there is at present any case for making *Cannabis* available for the extraction of antibiotic substances, and considered that the prohibition or restriction of the medical use of this plant should continue to be recommended by the international organs concerned.

With regard to the treatment of drug addicts, the Committee was in favour of a proposal that addicts should be committed to the care of a medical panel, as is done in the case of mental patients in general. This measure is intended to ensure adequate and complete treatment, but not to replace penalties for violations of the law.

* World Health Organization: Technical Report No. 211. Expert Committee on Addiction-producing Drugs—Eleventh Report. Pp. 16. 1 Swiss franc; 1s. 9d.; 0.30 dollar. (Geneva: World Health Organization; London: H.M.S.O.) 1961.

CULTURAL SEQUENCES IN NORTH-WEST AMERICA

In the past few years, evidence has been accumulating for a considerable variety in subsistence activities at an early date in North America. To the big-game hunters of the Plains have been added people who gathered seeds and plants and hunted small game in the Great Basin, and the archaic foragers of the East have proved to have begun earlier than we used to believe. The latest report* of Prof. L. S. Cressman's pioneer explorations in the north-western United States shows that yet another

*Trans. Amer. Phil. Soc., N.S., **50**, Part 10: *Cultural Sequences at the Dalles, Oregon—a Contribution to Pacific Northwest Prehistory*. By Prof. L. S. Cressman, in collaboration with David L. Cole, Wilbur A. Davis, Thomas M. Newman and Daniel J. Scheans. Pp. 108. (Philadelphia: American Philosophical Society, 1960.) 3 dollars.

way of life was followed by people who settled at the strategic point where the Columbia River passes through the Cascade Range on its westward journey. In historic times this was a great trading centre and the Indian inhabitants were noted middle-men.

The construction of the Dalles Dam was the occasion of an archæological salvage programme, and Prof. Cressman, of the University of Oregon, undertook the work on the left bank of the river. A good deal of the evidence had been destroyed by previous building work, but Cressman succeeded in establishing a continuous succession from at least 8000 B.C. to recent times. (The date is based on a composite radiocarbon sample from the lowest stratum, and Cressman considers that it could indicate a beginning date of 9000 B.C. or earlier.) At an unknown time before this, the release of some 500 cubic miles of water by the breaking of an ice dam had produced a fantastic flood through the gorge, obliterating most of the signs which could indicate an earlier occupation, although Cressman produces some rather slender evidence that there might have been one.

The succession falls into three main divisions, dated by four carbon dates. There is an early one lasting until a few centuries after 6000 B.C., followed by a transition lasting to about 4000 B.C., leading to a late period covering protohistoric and historic times. Certain types of artefact are confined to the early period and others to the late, and there are two other groups, one of which decreases from an early maximum while the other increases to a late one. The period of greatest interest to readers outside North America is the early one, to which antler and bone artefacts, bolas stones, certain types of projectile point, and burins are confined. The assemblage is interpreted as indicating a great exploitation of the salmon run, the hunting of large scavenger birds (the condor, etc.) with the bolas, and the hunting of small animals and, to a lesser extent, elk and deer; in short a dependence on the river and its immediate surroundings. Of great interest is the use of burins to cut antler and bone, in exactly the same way as was done at Prof. Grahame Clark's Mesolithic site at Star Carr in Yorkshire at about the same time, though many of the resulting artefacts differ. With the end of the early period not only the characteristic artefacts but also the animal, bird and fish bones disappeared entirely from the archæological record, a loss which has not yet been satisfactorily explained.

G. H. S. Bushnell

TOTAL MAGNETIC FIELD MEASUREMENTS BETWEEN NEW ZEALAND AND ANTARCTICA

By Dr. D. A. CHRISTOFFEL

Geophysics Laboratory, University of British Columbia, Vancouver

SOME results of a survey of the Earth's total magnetic field between New Zealand and Antarctica are presented in this article. No magnetic survey of this area has previously been made.

A proton magnetometer, of design similar to that described by Hill[1], was constructed at the Naval Research Laboratory, Auckland, New Zealand. It was installed aboard the Antarctic supply ship, H.M.N.Z.S. *Endeavour*, and was operated during this ship's Antarctic cruise between December 20, 1958, and February 15, 1959. One measurement was made each minute and the readings were recorded on a strip chart recorder to a significant value of 1γ.

Figs. 1 and 2 show charts of the area covered by the operation. The solid portions of the ship's track represent those parts over which measurements were obtained. The decimal figures beside the tracks give the values of the total field in gauss. These values have been smoothed, where necessary, to correct for local anomalies, but no corrections for time variations of the field have been made. The solid line contours have been drawn both from these measurements and also by reference to spot values obtained for various islands in the area and from the New Zealand Geomagnetic Survey maps[2]. The dotted line contours are from a total field chart issued by the U.S. Hydrographic Office, 1955 (ref. 3). It will be seen that south of lat. 55° S. the two sets of values diverge considerably. In particular, at lat. 61° S., long. 172° E., where the 1955 data show a maximum of 72,000γ, the value measured in the present instance was only 66,000γ. This discrepancy continues over the area of the Ross Sea shown in Fig. 2. Three isolated values which have been obtained from extrapolated rocket flight measurements[4] are shown in Figs. 1 and 2 with the values that were recorded marked beside them. It will be seen that these values agree with the measurements made in the present survey. Extrapolation of the field-values from the contours show that the maximum of 72,000γ would be located near a position lat. 70° S., long. 150° E.

In Fig. 3 two profiles of the total field which were obtained across an ocean trough are given. This trough is bounded to the north by a line of islands passing through Auckland, Campbell, Bounty and the Antipodes Islands, and the tracks cross it at a latitude of approximately 54° S. To the south the ocean trough is bounded by a portion of the mid-ocean ridge system. This section appears to run from just north of the Balleny Islands to Easter Island and the ship's tracks cross it at a latitude of approximately 68° S. The bathymetric depth over most of the 600 miles of the tracks shown in Fig. 3 was between 2,800 and 3,000 fathoms, and so far as could be ascertained from the depth measurement was flat. These depths were determined from explosive echo soundings made during the transit and from Admiralty Chart 788 and U.S.N. Hydrographic Office Chart No. 6636. The trough runs in a direction N. 74° E.

It will be seen that the peaks of anomaly have amplitudes of between 200 and 500γ, and that at least 25 of these may be correlated between the two

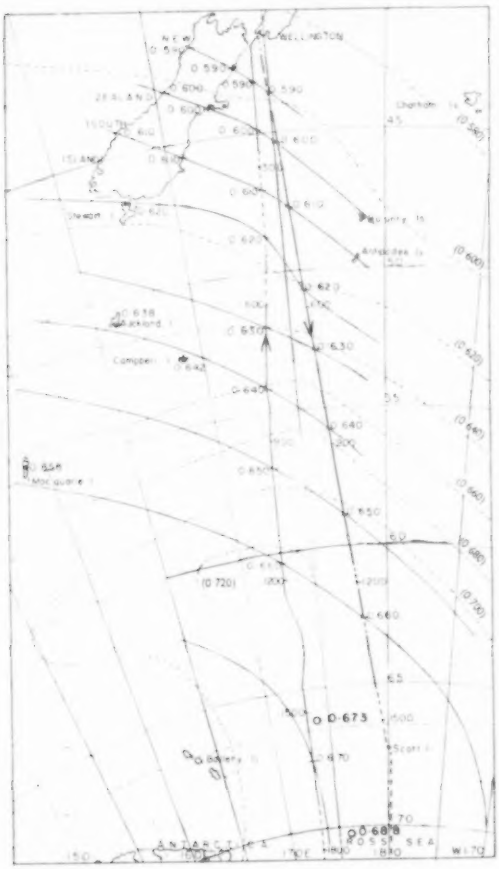


Fig. 1. Smoothed values of total-force magnetic field between Wellington, New Zealand, and Cape Adare, Antarctica
——, Contours extrapolated from values measured on present survey, and from stations in the area. Values in large numerals. – – –, Contours from U.S. Hydrographic Office, 1955 (values in parenthesis)

tracks in the 600 miles shown. The correlated lines are closely parallel to the direction of the bathymetric trough.

The anomalies are generally characterized by steep sides with, in some cases, flattened peaks. On the assumption that these are produced by dykes of magnetic material the thickness of which is comparable with the depth of the ocean, depth and susceptibility calculations have been made using the methods outlined by Henderson and Zietz[5]. It is found that in all cases the depth to the material producing the anomalies lies between 3,000 and 4,000 fathoms below sea-level, that is, only a short distance below the sea bottom. The contrast of susceptibility of the material is between 0·6 and 1·6 × 10^{-3} c.g.s. units and increases uniformly towards the south.

These anomalies bear a remarkable resemblance to those found in the comprehensive surveys conducted off the Californian Coast by the Scripps Institution of Oceanography[6]. In each case, the anomalies have similar amplitude and shape. They are found to occur on essentially flat ocean floors and do not correspond to bathymetric contours. The susceptibilities needed to produce the anomalies are high, indicating that the rocks must be of basic igneous origin.

An explanation advanced by Mason[5] is that these anomalies are produced by comparatively shallow

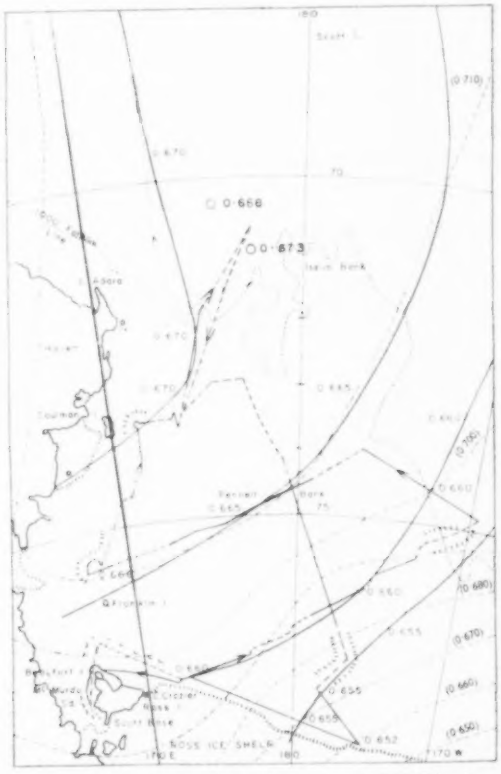


Fig. 2. Smoothed values of total-force magnetic field, Ross Sea, Antarctica
——, Contours plotted from values obtained, January 1959 (measured values shown in large numerals). – – –, Contours on U.S. Hydrographic Office Chart, 1955 (values in parenthesis)

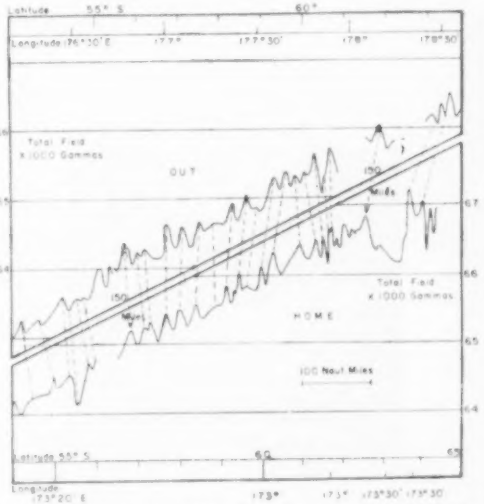


Fig. 3. Correlation, over 600 miles of track, between total field-measurements made on outward and homeward runs

lava flows which have spread out over the floor of the ocean. However, this does not explain why they should flow in parallel streams. It will be noticed that the anomalies off the Californian coast run approximately north and south, that is, parallel to the active primary mountain arc which extends down the west coast of America. In the present case the anomaly lines are parallel to the island arc in the north and the mid-ocean ridge to the south. An alternative explanation might be that, owing to the thrusts from either side, the sub-oceanic basalt layer has been buckled downwards, and fissures normal to the thrust direction have opened up, thus permitting the intrusion of lavas from beneath. This would explain both the nature and direction of the observed anomalies.

This work was part of a scientific programme undertaken by the Naval Research Laboratory, Auckland, New Zealand, and was carried out while I was in the New Zealand Defence Scientific Corps.

[1] Hill, M. N., *Deep-Sea Research*, **5**, 309 (1959).
[2] D.S.I.R. (New Zealand)—Geophysics Division: Total Force Isomagnetic Lines in New Zealand, Epoch 1950.5.
[3] U.S.N. Hydrographic Office Chart No. 1703. *The Total Intensity of the Earth's Magnetic Force for the Year 1955.*
[4] Cahill, L. J., *I.G.Y. Rocket Rep. Ser.* 4, 28 and 38 (1959).
[5] Henderson, R. G., and Zietz, I., *Geophysics*, **13**, 428 (1948).
[6] Mason, R. G., *Geophys. J.*, **1**, 320 (1958).

STAGNATION TEMPERATURE MEASUREMENTS IN A HYPERSONIC WIND-TUNNEL USING THE SODIUM LINE REVERSAL METHOD

By J. L. STOLLERY

Aeronautics Department, Imperial College of Science and Technology, London

THE sodium line reversal method[1] has recently been used to measure transient temperatures between 1,400° K. and 3,000° K.[2,3]. In the gun tunnel[4], stagnation temperatures in this range can be generated. Measurements were made in the tunnel working section by examining the flow between a blunt body and its bow shock-wave. The gas temperature in this zone is close to the stagnation value.

The experimental arrangement is described fully in ref. 5. The blunt body finally used was a 1¾-in. diameter disk. Originally, a thin layer of common salt was stuck to the front face of the model by moistening the surface. During the test period a 'cloud' of salt particles was 'liberated', interrupted the light beam and gave a false signal of absorption. Since far too much salt was introduced by this first method, the salt was powdered next and rubbed dry on the model surface. This proved to be both simple and effective.

The first tests were made with the background light source switched off. The flow around the model was viewed with the naked eye, as well as being recorded by the photomultiplier tube and oscilloscope. When the stagnation temperature was sufficiently high for useful measurements to be made, a yellow glow within the stand-off distance was clearly visible. It was soon obvious that at the large pressure ratios needed to generate measurable temperatures, the existing piston design was inadequate. Fig 1 shows a trace indicating emission throughout the 30-m.sec. running time but the dural piston body was deformed and the nylon skirt broke and burnt completely, so increasing the test-gas temperature.

During thirty-five runs various piston materials, designs and operating conditions were tried. Finally, an all-dural design generated measurable temperatures and lasted for about ten runs before structural failure. Fig. 2 shows a typical trace with a background source temperature of 1,510° K. Reading left to right at 5 m.sec./cm. it is apparent that 5 m.sec. after the oscilloscope is triggered there is an abrupt emission signal followed immediately by 2 m.sec. of absorption. These initial changes are thought to correspond to piston overshoot followed by piston reversal. The rest of the trace shows absorption, indicating that the gas temperature was less than 1,510° K. Sufficient runs were made to

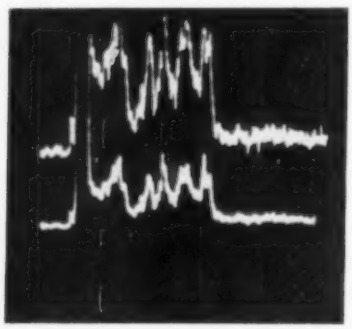


Fig. 1. P_4 = 2,515 lb./in.^{2} absolute; P_1 = 5 lb./in.^{2} absolute; P_4/P_1 = 503 (trace 17)

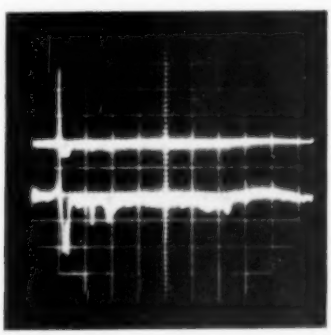


Fig. 2. P_4 = 3,015 lb./in.^{2} absolute; P_1 = 7·4 lb./in.^{2} absolute; P_4/P_1 = 407; delay, 8·7 m.sec.; source temperature = 1,510° K. (trace 88)

bracket the air stagnation temperatures generated under three operating conditions, namely :

P_4 (lb./in.² absolute	P_1 (lb./in.² absolute)	Damping plate
3,000	7·4	In
3,000	7·4	Out
3,000	10	Out

Though the temperatures measured were accurate to within ± 15° K., there are various corrections to be applied, the most serious of which is due to real gas effects. The sodium line reversal method measures the sodium electronic excitation temperature which, for a diatomic gas, 'follows' the vibrational temperature of the gas extremely closely[3]. If the gas is not in thermal equilibrium, the (vibrational) temperature measured will not be the true stagnation value. Gaydon and Hurle[4] have shown that the vibrational relaxation time for air is comparatively large and increases rapidly as pressure and temperature fall. This means that the nozzle flow will not be in vibrational equilibrium, and that the vibrational temperature will be much higher than the true (translational) flow temperature in the test-jet. On passing through the bow shock-wave, the air is heated again and the situation is reversed. There is insufficient time for the gas vibrational temperature to rise to the true stagnation value though the 'error' is now reasonably small due to the non-equilibrium in the test jet. Preliminary calculations indicate that the temperature measured is about 250° K. below the stagnation equilibrium value. Other corrections allowing for : (1) the effects of longitudinal and transverse temperature gradients ; (2) heat transfer to the disk, are discussed in ref. 5. All the corrections cause the sodium line reversal method to read low. The total correction is estimated to be 350° K.

The results are plotted in Fig. 3 and compared with : (*a*) the idealized estimated values; (*b*) isentropic compression; (*c*) the temperature behind a single reflected shock-wave; (*d*) other experimental data[7] the accuracy of which is ± 100° K. The comparison shows that the gun tunnel is generating temperatures in excess of the isentropic and reflected shock-values, but considerably below the perfect gas idealized estimates. What it does not show is the probable limit on P_4/P_1 of around 500 due solely to the mechanical strength of the piston. It seems likely that to generate temperatures above 2,000° K., wave-heating (zero piston-mass) will be the only solution.

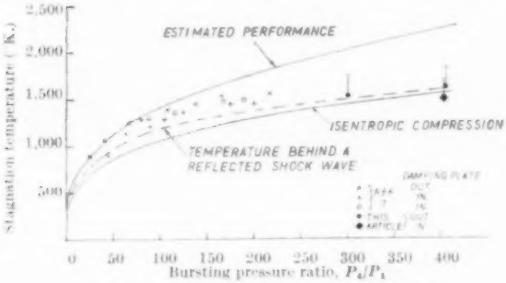


Fig. 3. Gun tunnel temperature measurements

The measured temperatures agree with the trend suggested by the A.R.D.E. experiments[7] and the measured temperature increase that results from removal of the damping plate is similar to that found by A.R.D.E.[7].

Conclusions : (1) Unless a dramatic improvement in piston design is made, enabling a very light, non-inflammable and extremely strong piston to be manufactured, the reservoir temperatures generated in the gun tunnel will be limited to 2,000° K. (2) Removal of the damping plate increases the stagnation temperature for a given bursting-pressure ratio. It also changes the reservoir pressure history to a castellated form, the first step of which has a magnitude which is greater than the bursting pressure, and a duration of nearly 20 m.sec. It would therefore seem sensible to use this period as the effective testing time and operate the tunnel with the damping plate out. (3) Since most traces showed either emission or absorption for the whole of the steady running time of 30 m.sec., and since the type of signal was changed by a 30° increase in source temperature, it is probable that the rate of temperature loss was less than 1,000 deg. K./sec.

This work was done during a visit to the National Research Council, Ottawa, Canada. The co-operative attitude and generous help of W. F. Campbell, R. Meyer and the tunnel technicians is most gratefully acknowledged.

[1] Gaydon, A. G., and Wolfhard, H. G., *Flames, their Structure, Radiation and Temperature* (Chapman and Hall, 1953).
[2] Agnew, J. T., Amer. Soc. Mech. Eng. Paper No. 51-*F*-6 (September 1951).
[3] Clouston, J. G., Gaydon, A. G., and Glass, I. I., *Proc. Roy. Soc.*, A, **248**, 429 (1958).
[4] Cox, R. N., and Winter, D. F. T., Advisory Group Aero. Res. and Develop. Report No. 139.
[5] Stollery, J. L., *Imperial College Aero. Dept. Tech. Note* No. 16.
[6] Gaydon, A. G., and Hurle, I. R., *Eighth Intern. Symp. on Combustion* (Pasadena, 1960).
[7] Cox, R. N., *A.R.D.E. Proc. Eleventh Symp. Colston Res. Soc.* (1959).

FORMATION OF HELICAL MICROFIBRILS FROM A STEROID ACID COMPLEX

By Dr. N. RAMANATHAN*, A. L. CURRIE† and J. ROSS COLVIN
Division of Applied Biology, National Research Council, Ottawa

THE demonstrated helical molecular structure of many biological polymers has led to the suggestion that super-helices may be formed from the initial coils and may be resolved in the electron microscope[1]. The idea is plausible and important since it provides a bridge between molecular chains and microscopic fibres, but definitive examples of its application are few in number. One example is the observation of a super-helical form in starch[2] and a second is the recent report of helical strands in sodium deoxycholate suspensions[3], which are helical

* N.R.C. Postdoctoral Fellow, 1958–59. Present address : Central Leather Research Institute, Madras, India.
† N.R.C. Postdoctoral Fellow, 1958–60.

at the molecular level[1]. We report here two additional properties of these helical strands and the results of an extension of observations to six related bile acids. The spontaneous association of deoxycholic acid to form coils at both the 10 Å. and 100 Å. level is of particular interest since no polymerization of the substance takes place[1].

The morphology of aggregates of seven related bile acids was examined by the electron microscope. Deoxycholic, cholic, apocholic, lithocholic, hyodeoxycholic and glycocholic acids were precipitated by hydrochloric acid from their sodium salts, washed with water, and recrystallized from aqueous ethanol. Taurocholic acid was prepared from its sodium salt with hydrochloric acid, precipitated by ethanol and washed thoroughly with ethanol. All acids except taurocholic were dissolved in ethanol and added dropwise to de-ionized water or an appropriate buffer, until a slightly cloudy suspension was obtained. Taurocholic acid was added directly to water. Preparations without buffer were dried directly on grids covered with a carbon film. Preparations in buffers were dialysed overnight on 'Formvar' films floating on water. After mounting on grids and drying, all specimens were shadowed at an angle of 15° with gold–palladium (60–40).

Of the above bile acids, only deoxycholic formed helical microfibrils when suspended in de-ionized water at *p*H 5 or in phosphate buffers up to *p*H 7·4 (Fig. 1). Above *p*H 7·4, no microfibrils were detectable. When water suspensions of deoxycholic acid were dried on carbon films after zero, two, four or eight hours standing, the form of the helical microfibrils changed progressively to rod-shaped aggregates (Fig. 2). After 8 hr., the super-helices had almost disappeared.

A further property of all preparations of helical microfibrils from deoxycholic acid was a right-handed twist, presumably reflecting a characteristic asymmetry of the form of the molecule (Fig. 1). This asymmetry is not an artefact of the conditions of preparation for comparative preparations of helical microfibrils from potassium palmitate[2] consist of both left- and right-handed helices in approximately equal numbers (Fig. 3).

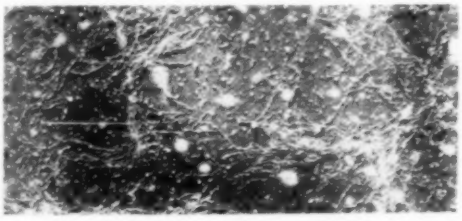


Fig. 3. Microfibrils of potassium palmitate

Deoxycholic acid fibres drawn from a solution buffered with glycylglycine gave an X-ray diffraction pattern identical with that reported previously[1]. When these fibres were dispersed in water on carbon-covered grids, they also showed typical helical microfibrillar substructure.

Of the remaining acids, only lithocholic formed aggregates which showed as bundles of straight microfibrils (Fig. 4).

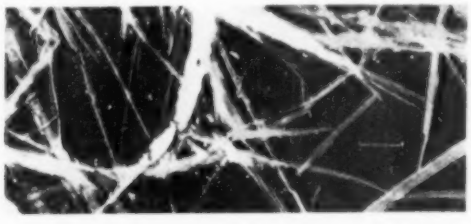


Fig. 4. Lithocholic acid bundles

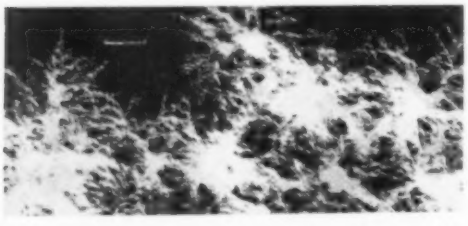


Fig. 1. Helical microfibrils of deoxycholic acid suspended in water and dried immediately

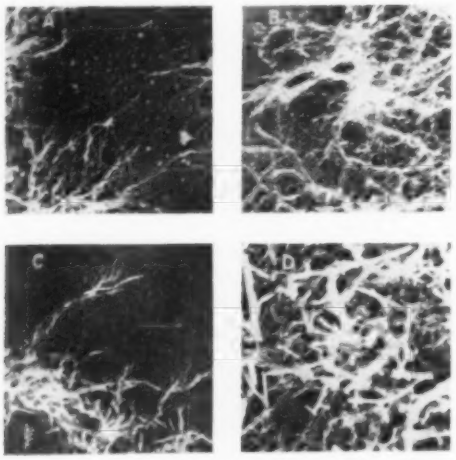


Fig. 2. Microfibrils of deoxycholic acid formed after standing for: *A*, 0 hr.; *B*, 2 hr.; *C*, 4 hr.; *D*, 8 hr.; all of equal magnification

The present observations, coupled with those of others[3,4], illustrate a particular example of a class of systems analysed by Pauling in qualitative terms, which are of interest in themselves and which may afford a model for some cases of biological fibrogenesis[1]. The asymmetric, un-ionized deoxycholic acid molecules in aqueous solution quickly and spontaneously pack together under the influences of London dispersion forces to form extended linear molecular helices, which are reflected in a high viscosity and the capacity to form brittle, crystalline drawn fibres. Small systematic deviations in the regularity of stacking of the steroid groups cause the molecular helices themselves to have a screw-form, leading to characteristic helical microfibrils or bundles of such microfibrils. Above neutrality, the association of the un-ionized bile-acid molecules is progressively destroyed by Coulomb repulsion of the carboxyl groups. Minor variations of molecular structure (that is, introduction of a double bond in the 8–14 position of deoxycholic acid to give apocholic acid) may eliminate the close packing necessary to give microfibrils or the asymmetry

required for a helix (for example, lithocholic acid which is deoxycholic lacking only the hydroxyl group at C_{12}). As might be expected, helical microfibrils are appreciably stronger than straight aggregates since lithocholic acid forms no detectable complexes comparable to those of deoxycholic[4], although it does form straight rods of a comparable size. However, why the packing of the molecular helices in the microfibrils is only metastable with respect to the straight form is not yet clear.

[1] Pauling, L., *Disc. Farad. Soc.*, **13**, 170 (1953).
[2] Heyn, A. N. J., *Textile Res. J.*, **29**, 366 (1959).
[3] McCrea, J. F., and Angeret, S., *Biochim. Biophys. Acta*, **42**, 355 (1960).
[4] Rich, A., and Blow, D. M., *Nature*, **182**, 423 (1958).
[5] Hattiangdi, G. S., and Swerdlow, M., *J. Res. Nat. Bur. Stand.*, **42**, 343 (1949).

THE ACTIVE SITE AND MECHANISM OF ACTION OF BOVINE PANCREATIC RIBONUCLEASE

By DOROTHY FINDLAY, D. G. HERRIES, Dr. A. P. MATHIAS, Dr. B. R. RABIN and C. A. ROSS

Department of Biochemistry, University College, London

BOVINE pancreatic ribonuclease (RNase) is the only enzyme the primary structure of which is known[1]. A great deal of work has been done on the secondary and tertiary structure of this protein, but it is not possible to make any definite formulation of the conformation in aqueous solution[2]. In fact, several catalytically active, but physically different conformations can be produced[3]. Richards[4] has shown that subtilisin hydrolyses RNase between amino-acid residues 20 and 21 (numbering from N-terminal) without loss of activity. The peptide of 20 amino-acid residues (S-peptide) remains attached to the protein moiety, from which it may be separated by fractionation with trichloroacetic acid. The enzyme may be reconstituted, with full catalytic activity, by mixing the two fragments in aqueous solution.

RNase has four histidine residues at positions 16, 48, 105 and 119. Weil and Seibles[5], on the basis of photo-oxidation investigations, suggested that one or more of these histidine residues was associated with the active site. Histidine residue 119 reacts with iodoacetate or bromoacetate, with loss of catalytic activity[6], far more readily than the others at pH values between 5 and 6. Vithayathil and Richards[7] have shown that histidine 16 of modified S-peptide may be alkylated with iodoacetate with no loss of activity in the reconstituted enzyme. We have accumulated evidence in this laboratory[8] that two histidine residues are probably involved at the catalytic site of RNase and this, together with other data, has been used to formulate a mechanism of action of this enzyme.

Detailed investigation of the pH-activity curve of the hydrolysis of cytidine 2′ : 3′-phosphate has shown that the reaction can be interpreted in terms of the following scheme:

$$\begin{array}{ccccc} EH_2 & \overset{K_b}{\rightleftharpoons} & EH & \overset{K_a}{\rightleftharpoons} & E \\ & & \updownarrow & & \\ EH_2S & \overset{K_b}{\rightleftharpoons} & EHS & \overset{K_{a'}}{\rightleftharpoons} & ES \\ & & \downarrow & & \\ & & \text{products} & & \end{array}$$

S represents the substrate; EH_2, EH and E represent the enzyme at different stages of ionization; charges are not specified. The constants are defined thus:

$$K_b = \frac{[EH][H]}{[EH_2]} \qquad K_a = \frac{[E][H]}{[EH]}$$

$$K_{b'} = \frac{[EHS][H]}{[EH_2S]} \qquad K_{a'} = \frac{[ES][H]}{[EHS]}$$

At any single pH the initial velocity can be fitted accurately to the Michaelis equation:

$$V = \frac{k_3.[E_0][S]}{K_m + [S]} \tag{1}$$

where E_0 is the total enzyme concentration. The variation of the parameters of equation (1) with pH is shown in Fig. 1. The results fit the following expressions:

$$k_3 = \frac{\bar{k}_3}{1 + \dfrac{[H]}{K_{b'}} + \dfrac{K_{a'}}{[H]}} \tag{2}$$

$$K_m = \frac{\bar{K}_m\left(1 + \dfrac{[H]}{K_b} + \dfrac{K_a}{[H]}\right)}{\left(1 + \dfrac{[H]}{K_{b'}} + \dfrac{K_{a'}}{[H]}\right)} \tag{3}$$

where k_3 and K_m are constants independent of pH. The values obtained for the constants are shown in Table 1. Serious reservations have to be made in interpreting results such as these[9], though, as a first approximation, it is permissible to identify the acid dissociation constants of equations (2) and (3) with those of the reaction scheme. The values of K_b and K_a suggest that both are dissociations from imidazole groups of histidine residues. One of these is required in the base form and the other in the acid form for catalytic activity. The measured constants are 'macroscopic'[10]; but, because of their relatively large separation, they probably do not differ greatly from the intrinsic pK values of the acid and base sites.

Table 1. pK VALUES OF THE GROUPS AT THE ACTIVE SITE OF RIBONUCLEASE OBTAINED FROM THE KINETICS OF THE HYDROLYSIS OF CYTIDINE 2′ : 3′-PHOSPHATE AT IONIC STRENGTH 0·2 AND 25° C.

Free enzyme	Enzyme–substrate complex
$pK_b = 5{\cdot}22$	$pK_{b'} = 6{\cdot}30$
$pK_a = 6{\cdot}78$	$pK_{a'} = 8{\cdot}10$

If there were two groups on the enzyme, one an acid, the other base, which bind the substrate, the formation of the enzyme-substrate complex would result in lowering the pK of the group required in the base form and raising the pK of the group required in the acid form[9,*]. It can be seen from Table 1 that $pK_{a'}$ is greater than pK_a and $pK_{b'}$ is greater than pK_b; that is, the pK values of the groups at the active site are both greater in the enzyme-substrate complex than in the free enzyme; after binding the substrate, both

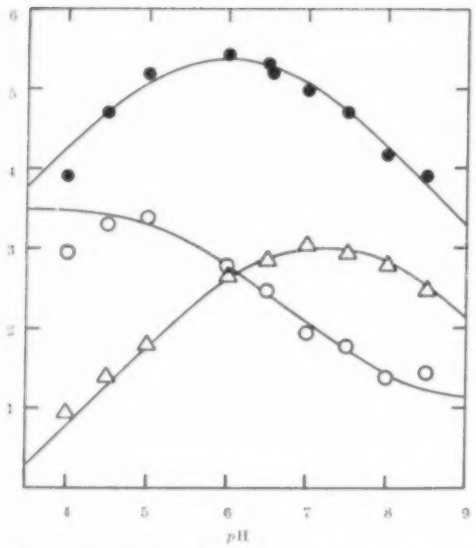


Fig. 1. Variation with *p*H of the kinetic parameters for the hydrolysis of cytidine 2′ : 3′-phosphate by ribonuclease at 25° C. and ionic strength 0·20. The points shown are experimental and the lines are calculated using the results in Table 1. ●—●—●, log k_2/K_m; △—△—△, log k_2; ○—○—○, pK_m

groups become weaker acids. This is evidence that the base group does not interact with the cyclic phosphate since its *p*K shifts in the wrong direction on formation of the enzyme-substrate complex. Binding at only the acid site would normally require $K_{a'}$ to be zero, since *ES* could not exist. A positive value of $K_{a'}$ indicates that, in addition to binding at the acid site, interaction occurs with one or more groups on the protein which do not change their states of ionization over the *p*H-range used (4–8·5). This interaction might well involve the pyrimidine ring and consequently partially determine the specificity. It is suggested that the base site is required to interact with the other reactant, water or an alcohol, in the hydrolysis, or alcoholysis, of cytidine 2′ : 3′-phosphate. Evidence for the existence of such a 'water-binding' site has already been presented[11], and other data consistent with this interpretation have recently been obtained (Findlay, D., unpublished work).

Investigation of the effects of organic solvents on the *p*H activity curve shows that the groups with dissociation constants $K_{b'}$ and $K_{a'}$ are cationic acids (Findlay, D., unpublished work). In these experiments the *p*H activity curve was determined, under conditions in which the substrate did not limit the rate, in water, 50 per cent v/v aqueous dioxane and 50 per cent v/v aqueous formamide. The difficulties of measuring and interpreting the *p*H of mixed solvents were circumvented by determining the three *p*H activity curves in buffers of two different types of charge: (*a*) cationic acids, $HR^+ = H^+ + R$; (*b*) neutral acids, $HR = H^+ + R^-$. The *p*K's of acids of type (*a*) decrease slightly in the presence of organic solvents, whereas those of type (*b*) increase considerably[12]. The *p*H activity curve shifts on addition of organic solvents with buffers of type (*b*) (Fig. 2), but scarcely at all in buffers of type (*a*) (Fig. 3). Since under the conditions employed the enzyme is saturated with substrate, any changes caused by the organic solvents are probably not due to changes in the binding constant of the substrate, but to changes in the *p*K's of buffers and enzyme-substrate complex. Both dissociations from the enzyme-substrate complex behave in the same way as buffers of type (*a*) and very differently from buffers of type (*b*). This confirms that they are probably both cationic acids. A detailed discussion of this problem will be presented elsewhere.

Further details of the nature of the active site has been obtained by spectrophotometric investigations[13]. Cytidine 2′-phosphate and cytidine 3′-phosphate are both competitive inhibitors of the hydrolysis of cytidine 2′ : 3′-phosphate (ref. 14 and Herries, D. G., and Ross, C. A., unpublished work), and both form complexes with the enzyme which may be

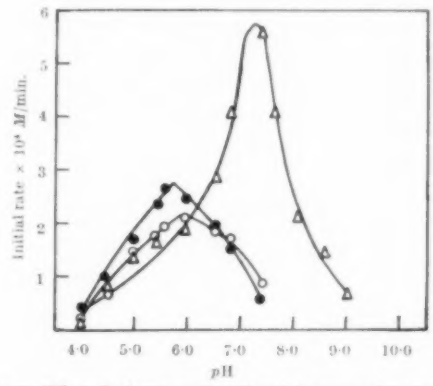


Fig. 2. Effect of solvents on the *p*H activity curve of the hydrolysis of cytidine 2′ : 3′-phosphate by ribonuclease in 'neutral acid' buffers at 25° C. and ionic strength 0·25. The abscissa is the *p*H of the appropriate buffer/salt mixture in water. The solvents used were: △—△—△, water; ●—●—●, 50 per cent v/v dioxane; ○—○—○, 50 per cent v/v formamide. The concentrations of enzyme and substrate were, respectively, 0·05 *M* and 0·0125 mgm./ml. The following buffers were used: *p*H's 4·00, 4·52, 4·99 and 5·39, acetate; *p*H's 5·56, 5·96 and 6·53, maleate; *p*H's 6·82 and 7·40, pentane 3,3-dicarboxylate (pK_3); *p*H's 7·65, 7·87, 8·08, 8·59 and 9·05, *p*-phenolsulphonate

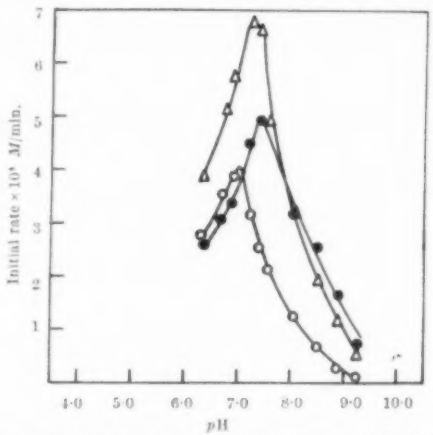


Fig. 3. Effect of solvents on the *p*H activity curve of the hydrolysis of cytidine 2′ : 3′-phosphate by ribonuclease in 'cationic acid' buffers at 25° C. and ionic strength 0·25. The abscissa is the *p*H of the appropriate buffer/salt mixture in water. The solvents used were: △—△—△, water; ●—●—●, 50 per cent v/v dioxane; ○—○—○, 50 per cent v/v formamide. The concentrations of enzyme and substrate were, respectively, 0·05 *M* and 0·0125 mgm./ml. The buffers used were: *p*H's 6·38, 6·75, 6·91, 7·23 and 7·35, ethylenediamine (pK_1); *p*H's 7·60, 8·10 and 8·53, N-ethylmorpholine; *p*H's 8·92 and 9·30, ethylenediamine (pK_2)

detected spectrophotometrically, as shown in Figs. 4 and 5. The computed spectra in these figures were obtained by assuming additivity of the absorbancies of the components, and they differ significantly from the measured spectra. This indicates formation of a complex. Alkylation of histidine residue 119 by bromoacetic acid by the method of Barnard and Stein[6a], to produce enzymically inactive CMRNase, does not alter the enzyme-inhibitor interactions as judged by the spectrophotometric shifts[13b]. Moreover, a clear-cut interaction between the substrate cytidine 2′ : 3′-phosphate and CMRNase can be demonstrated spectrophotometrically as shown in Fig. 6. This suggests that residue 119 does not interact directly with cytidine 2′ : 3′-phosphate but is the water-binding site proposed by Findlay, Mathias and Rabin[11]. Kinetic data suggest that inhibition of RNase by

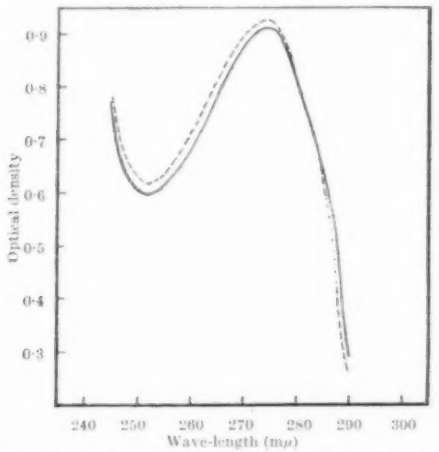


Fig. 4. Absorption spectra of a mixture of cytidine 2′-phosphate and ribonuclease (each $5{\cdot}44 \times 10^{-5}$ *M*) in N-ethylmorpholine buffer at *p*H 6·90, ionic strength 0·20 and 25° C. ——, measured spectrum; – – –, computed spectrum obtained by adding the absorbancies of the components

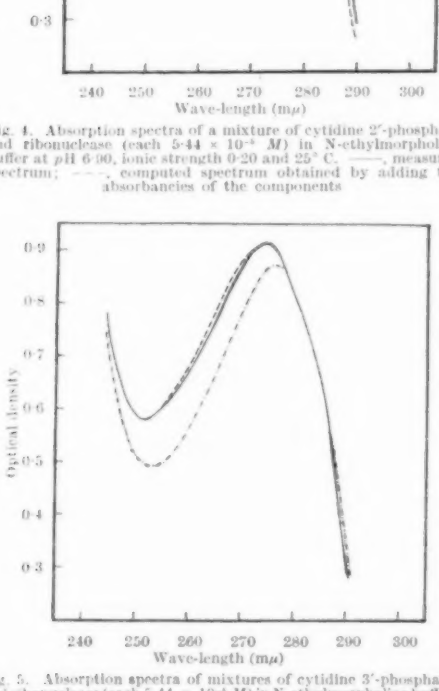


Fig. 5. Absorption spectra of mixtures of cytidine 3′-phosphate and ribonuclease (each $5{\cdot}44 \times 10^{-5}$ *M*) in N-ethylmorpholine buffer at *p*H 6·90, ionic strength 0·20 and 25° C. ——, measured spectrum; – – –, computed spectrum (cytidine-3′-phosphate + RNAse); – · – · –, in the presence of 2×10^{-4} *M* zinc chloride (measured spectrum)

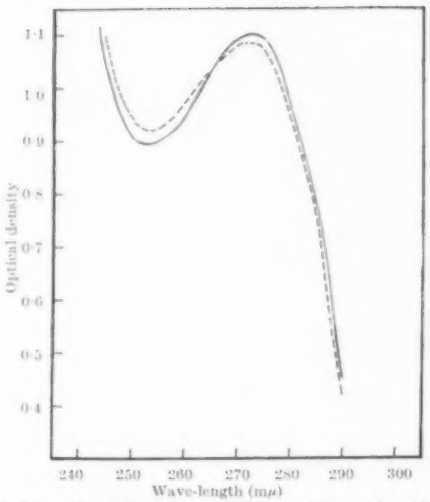
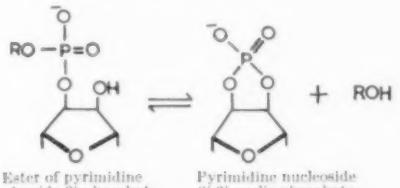


Fig. 6. Absorption spectra of a mixture of cytidine 2′ : 3′-phosphate and CMRNase (ribonuclease with histidine residue at position 119 carboxymethylated) in N-ethylmorpholine buffer at *p*H 6·90, ionic strength 0·20 and 25° C. The concentrations of both components were $5{\cdot}44 \times 10^{-5}$ *M*. ——, measured spectrum; – – –, computed spectrum obtained by adding the absorbancies of the components

zinc ions[15] is associated with the formation of a ternary complex of RNase, zinc (II) and cytidine 3′-phosphate, the product of the reaction. This ternary complex can be observed spectrophotometrically (Fig. 5), but does not form with CMRNase, zinc (II) and cytidine 3′-phosphate nor with RNase, zinc (II) and cytidine 2′-phosphate. This is consistent with the binding of zinc (II) to residue 119 and provides further support for the view that this residue is not involved in binding cytidine 2′ : 3′-phosphate or cytidine 3′-phosphate. It is important to note that none of the above evidence excludes the possibility that residue 119 is involved in the formation of enzyme – substrate complexes of esters of cytidine 3′-phosphate.

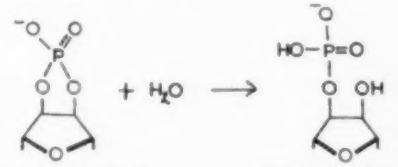
Any mechanism proposed for the action of RNase must explain the finding that cytidine 2′-phosphate is the most powerful inhibitor of the three cytidine



Ester of pyrimidine nucleoside-3′-phosphate — Pyrimidine nucleoside 2′,3′-cyclic phosphate

REACTION I

Fig. 7



Pyrimidine nucleoside 2′,3′-cyclic phosphate — Pyrimidine nucleoside 3′-phosphate

REACTION II

Fig. 8

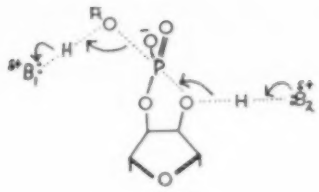


Fig. 9

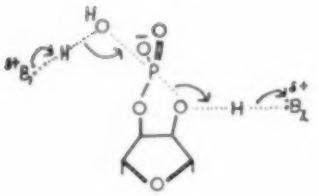


Fig. 10

monophosphates. This would suggest that one of the interactions in the enzyme – substrate or enzyme – inhibitor complex is between the 2′ cytidine oxygen and a positively charged acid-group on the protein. Of the three cytidine monophosphates, cytidine 2′-phosphate has the most basic oxygen in the 2′ position.

RNase catalyses two reactions[16] shown in Figs. 7 and 8. Both these reactions involve nucleophilic displacements about the phosphorus atom. The attacking and departing groups are, respectively: reaction I (Fig. 7), 2′ oxygen and O*R* ; reaction II (Fig. 8), water oxygen and 2′ oxygen. The attacking reagent would be assisted by co-ordination with a base group and the removal of the departing group would be assisted by co-ordination to an acid group. Thus the acid-base requirements for reaction II are the reverse of those for reaction I in the forward direction and the same as those for reaction I in the reverse direction. We have presented evidence that both these groups are histidine residues and these are represented, in the acid form, by B_1H^+ and B_2H^+. The mechanism we suggest, in which the dotted lines are bonds being formed or broken and curved arrows the direction of electron displacements, is illustrated in Figs. 9 and 10. If *R*OH replaces HOH in Fig. 10, this represents the reverse of reaction I. Reaction I in the forward direction requires the species B_1H^+ and B_2; reaction II, and reaction I in the reverse direction, require B_1 and B_2H^+. This conforms with the principle of conjugate requirements[17]. B_1 is possibly residue 119 and B_2 either 48 or 105.

We are indebted to the Central Research Fund, University of London, for a grant for the purchase of automatic titration equipment and to the Wellcome Trust for a grant for the purchase of a Cary recording spectrophotometer. The following personal grants are acknowledged: Ontario Research Foundation (to D. F.); Department of Scientific and Industrial Research (to D. G. H.); Medical Research Council (to C. A. R.).

Note added in proof. Recent work from the Rockefeller Institute, New York[18], is in accord with our hypothesis of the structure of the active site of RNase. It was shown that the unique reactivity of histidine 119 towards iodoacetate is probably due to interaction of the carboxyl group of the alkylating reagent with the imidazole group, in the cationic form, of another histidine residue. The separation of the two imidazole groups required for this electrostatic enhancement is of the same order as that expected for the acid/base pair at the active site of RNase.

[1] (*a*) Hirs, C. H. W., Moore, S., and Stein, W. H., *J. Biol. Chem.*, **235**, 633 (1960). (*b*) Anfinsen, C. B., *Symposium on Protein Structure*, edit. Neuberger, A., 223 (Methuen, London, 1958).

[2] (*a*) Yang, J. T., and Doty, P., *J. Amer. Chem. Soc.*, **79**, 761 (1957). (*b*) Tanford, C., Hauenstein, J. D., and Rands, D. G., *J. Amer. Chem. Soc.*, **77**, 6409 (1955). (*c*) Scheraga, H. A., Chu, C. Y., Hermans, J., and Schildkraut, C. L., *Aminoacids, Proteins and Cancer Biochemistry*, edit. Edsall, J. T., 31 (Acad. Press, New York, 1960).

[3] Shapira, R., and Parker, S., *Biochem. Biophys. Res. Comm.*, **3**, 200 (1960).

[4] (*a*) Richards, F. M., *Proc. U.S. Nat. Acad. Sci.*, **44**, 162 (1958). (*b*) Richards, F. M., and Vithayathil, P. J., *J. Biol. Chem.*, **234**, 1459 (1959).

[5] Weil, L., and Seibles, T. S., *Arch. Biochem. Biophys.*, **54**, 368 (1955).

[6] (*a*) Stein, W. D., and Barnard, E. A., *J. Mol. Biol.*, **1**, 350 (1959). (*b*) Barnard, E. A., and Stein, W. D., *ibid.*, **1**, 339 (1959). (*c*) Gundlach, H. G., Stein, W. H., and Moore, S., *J. Biol. Chem.*, **234**, 1754 (1959).

[7] Vithayathil, P. J., and Richards, F. M., *J. Biol. Chem.*, **235**, 2343 (1960).

[8] Herries, D. G., *Biochem. Biophys. Res. Comm.*, **3**, 666 (1960).

[9] (*a*) Laidler, K. J., *The Chemical Kinetics of Enzyme Action* (Oxf. Univ. Press, 1958). (*b*) Dixon, M., and Webb, E. C., *Enzymes*, chap. 4 (Longmans, Green, 1958). (*c*) Bruice, T. C., and Schmir, G. L., *J. Amer. Chem. Soc.*, **81**, 4552 (1959).

[10] Edsall, J. T., and Wyman, J., *Biophysical Chemistry*, **1**, chap. 9 (Acad. Press, New York, 1958).

[11] Findlay, D., Mathias, A. P., and Rabin, B. R., *Nature*, **187**, 691 (1960).

[12] (*a*) Robinson R. A., and Stokes, R. H., *Electrolyte Solutions*, 538 (Butterworths, London, 1959). (*b*) Mandel, M., *Industr. Chim. Belg.*, 721 (1958).

[13] (*a*) Hummel, J. P., Nelson, C. A., and Ploeg, D. V., *Fed. Proc.*, **19**, 344 (1960). (*b*) Mathias, A. P., Rabin, B. R., and Ross, C. A., *Biochem. Biophys. Res. Comm.*, **3**, 625 (1960).

[14] Hummel, J. P., Flores, M., and Nelson, G., *J. Biol. Chem.*, **233**, 717 (1958).

[15] Zittle, C. A., *J. Biol. Chem.*, **163**, 111 (1946).

[16] (*a*) Markham, R., and Smith, J. D., *Biochem. J.*, **52**, 552 (1952). (*b*) Brown, D. M., and Todd, A. R., *J. Chem. Soc.*, 2040 (1953).

[17] Rabin, B. R., *Biochemical Society Symposia*, **15**, 42 (1958).

[18] Stark, G. R., Stein, W. H., and Moore, S., *J. Biol. Chem.*, **236**, 436 (1961).

VISUAL PIGMENT OF GRAPSOID CRABS

By MICHAEL H. BRIGGS

Department of Chemistry, Victoria University of Wellington, New Zealand

WITHIN the past few years a number of research workers have isolated visual pigments from a variety of arthropods. Kampa[1] has extracted a pigment from the eyes of a euphausiid crustacean, *Euphausia pacifica*, while Fisher and Goldie[2] have prepared a similar photosensitive substance from the eyes of another member of this order, *Meganyctiphanes norvegica*. Wald and Hubbard[3] have extracted a pigment from the eyes of the decapod crustacean, *Homarus americanus*, and an insect visual pigment has been obtained by Goldsmith[4] from *Apis mellifera*. The first reported arachnoid visual pigment is from *Limulus*[5].

It is apparent that the arthropods offer an excellent opportunity for the study of comparative visual biochemistry[6]. The numerous arthropod species

(estimated at 750,000 (ref. 7)), all possess eyes, and, moreover, present tremendous variations in nutrition, ecology, etc.—factors that probably have considerable effects on the visual mechanisms.

This article reports the extraction of visual pigments from the eyes of two species of grapsoid Crustacea. The pigments from the two species are identical, and proved to be rhodopsins of the type previously investigated by other workers from vertebrates and invertebrates[8].

The animals used were adult specimens of *Hemigrapsus edwardsii* and *Leptograpsus variegatus*, collected locally. Experiments were conducted within a few hours of capture, the animals being contained in sea-water.

In experiments to determine the vitamin A content of the eyes, the whole eyestalks were removed and immediately stored in a deep freeze until required. Visual pigments were extracted from freshly removed eyes obtained from animals previously dark-adapted for 3 hr.

Vitamin A was determined by techniques based on those of Wald and Burg[9]. The eye tissues were ground with anhydrous sodium sulphate until dry, and then repeatedly extracted with petroleum ether until the extract was colourless. A further extraction of the tissues was made with acetone to release any protein-bound carotenoids.

The petroleum ether extract was chromatographed on Merck alumina. Vitamin A esters were eluted from the column with 4 per cent acetone in petroleum ether, and free vitamin A alcohol with 40 per cent acetone in petroleum ether. Both these fractions were saponified with 6 per cent potassium hydroxide in methanol for 20 min. at 40° C., and then separately brought into solution in hexane. The absorption spectra of these solutions were determined immediately. The spectra were obtained a second time after 15-min. irradiation with sunlight in the presence of an added 5 μgm. of iodine. The vitamin A of these solutions was brought next into solution in chloroform and a Carr–Price reaction conducted by the addition of saturated antimony trichloride solution in chloroform. From the extinction coefficients of these solutions at 618 mμ the total vitamin A content was calculated.

Visual pigments were isolated from the fresh, dark-adapted eyes by techniques based on those of previous workers[1,3,5]. All stages of preparation were conducted in darkness, or with a dim photographic red light as the only source of illumination.

The eyes were thoroughly ground with a mortar and pestle, and then in a small Potter–Elvehjem glass tissue homogenizer. The ground tissues were repeatedly extracted with petroleum ether to remove light-stable pigments. The resulting tissues were extracted with a small volume of 2 per cent aqueous digitonin, and the extract filtered through sintered glass. The absorption spectrum of this solution was determined immediately, and again after 30 min. in darkness at room temperature. The solution was next exposed to sunlight for 20 min. and the absorption spectrum again determined in the presence of 0·1 *M* hydroxylamine. A difference spectrum was obtained by subtracting the optical density readings of the bleached solution from those of the unbleached solution.

To a portion of the unbleached extract acetone was added and the mixture shaken with ethyl ether. The ether fraction was separated, dried and the residue taken up in chloroform. The absorption spectrum of this extract was determined alone, and again after a Carr–Price reaction.

Extracts of the eyes of both species contained free vitamin A alcohol and vitamin A esters. Astaxanthin and other carotenoids, probably xanthophyll and beta-carotene, were also present. The total vitamin A content of the eye extracts was calculated on the basis that the extinction coefficient, E (1 per cent, 1 cm.), of the vitamin A–antimony trichloride product in chloroform is 4,400 at 618 mμ [9]. The values calculated by taking the means of several determinations are given in Table 1. These levels are comparable with the vitamin A contents reported for other crustacean species[10–14].

Table 1. Vitamin A in the Eyes of Grapsoid Crabs

	Hemigrapsus edwardsii	*Leptograpsus variegatus*
Total vitamin A (μgm. per eye)	1·3	1·5
Free vitamin A alcohol (per cent of total)	15	11
Esterified vitamin A (per cent of total)	85	89

The addition of iodine and exposure to white light of the solutions containing the extracted vitamin A led to an easily detected increase in extinction around 325 mμ. Moreover, the absorption maximum of the vitamin A in the chromatographed extracts was at 319–321 mμ before this treatment, and at 325–326 mμ afterwards. As the concentration of vitamin A in the extracts was known from the Carr–Price reactions, it was possible to calculate the extinction coefficients (E). The average E (1 per cent, 1 cm.) for all the extracts containing vitamin A (including those derived from the ester forms by saponification) was 1,225, the range of the samples being 1,210–1,255.

These results indicate that the vitamin A from the eyes of these crabs is present largely in the neo-*b* form (the 11-mono-*cis* isomer). This is the only vitamin A isomer to give a large change in extinction on exposure to iodine and sunlight, to have a $\lambda_{max.}$ at 319–321 mμ, and to have an extinction coefficient at 320 mμ of approximately 1,200 (ref. 8). This deduction was confirmed by measuring the ratio of $E_{max.}$ of the original extracts at 320 mμ to the $E_{max.}$ at 325 mμ of the solutions after isomerization. The calculated ratios ranged from 1·44 to 1·50, with a mean of 1·47. The ratio for neo-*b* vitamin A is 1·45 ± 0·05 (ref. 8).

Visual pigments were successfully isolated from the ground eyes of both species by digitonin extraction. The difference spectra of these pigments from both species were identical within experimental errors. The result of a typical determination is given in Fig. 1. The photosensitive pigment has an absorption maximum at 513 ± 2 mμ. No change in spectrum was detected after the pigment solutions had been kept at room temperature for 30 min.

Examination of the spectrum of the products produced by the bleaching of the crab rhodopsin revealed the presence of a second pigment with $\lambda_{max.}$ 495 mμ. This pigment appears to be in many ways analogous to the metarhodopsin obtained by Wald and Hubbard[3] from the lobster. On standing in the dark, the crab metarhodopsin is gradually converted to a mixture of retinene and opsin. This change is demonstrated by the slow decline in intensity of absorption at 495 mμ, and by the increased quantity of retinene extractable from the solution. The conversion of crab metarhodopsin to retinene and opsin is complete within 2 hr.

Three compounds were identified in the ether extract of the acetone-treated, unbleached solution of crab rhodopsin. A narrow absorption due to vitamin A was detected at 325 mμ, a second absorp-

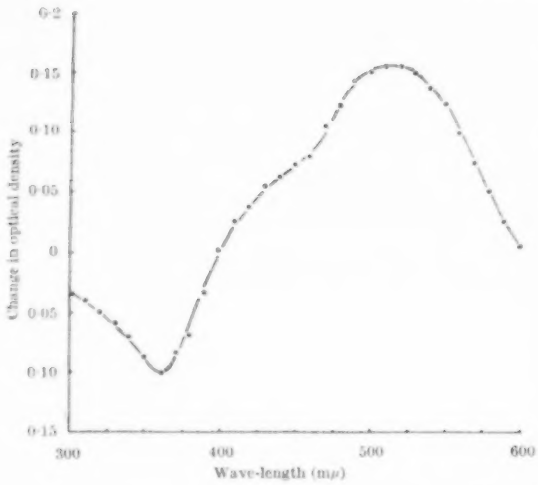


Fig. 1. Difference spectrum of rhodopsin from grapsoid crabs. Since retinene oxime has no absorption above 450 mμ, the difference spectrum is equivalent to the true absorption spectrum of the rhodopsin above this wave-length. The minimum around 362 mμ corresponds to the absorption of retinene oxime

tion at 366 mμ indicated the presence of retinene, while a broad-band absorption in the blue-green at around 470 mμ was assumed to be due to astaxanthin. The presence of vitamin A and retinene in the extract was confirmed by a Carr–Price reaction which yielded an absorption spectrum with maxima at 618 mμ (vitamin A) and at 666 mμ (retinene).

These results indicate that the digitonin extract contains a variety of compounds other than crab rhodopsin. The vitamin A detected is presumably a contaminant due to the incomplete extraction of the tissues with petroleum ether. It is unlikely to be present as a protein complex. The astaxanthin also may be a contaminant of a similar nature, but the amounts detected favour the view that the digitonin extracts an astaxanthin–protein complex from which free astaxanthin is liberated by the acetone treatment.

Considered as a whole, the above results demonstrate that crab rhodopsin is a protein with a retinene chromophore. The preponderance of neo-*b* vitamin A in the crab eyes is strong evidence that the retinene chromophore is also in the hindered 11-mono-*cis* configuration, and is thus analogous to previously isolated rhodopsins[6].

[1] Kampa, E. M., *Nature*, **175**, 996 (1955).
[2] Fisher, L. R., and Goldie, E. H., *Proc. Fifteenth Intern. Cong. Zool., Lond.*, 533 (1959).
[3] Wald, G., and Hubbard, R., *Nature*, **180**, 278 (1957).
[4] Goldsmith, T. H., *Proc. U.S. Nat. Acad. Sci.*, **44**, 123 (1958).
[5] Hubbard, R., and Wald, G., *Nature*, **186**, 212 (1960).
[6] Wald, G., in *Comparative Biochemistry*, **1**, 311 (Academic Press, New York, 1960).
[7] Spector, W. S. (ed.), *Handbook of Biological Data*, 533 (Saunders, Philadelphia, 1956).
[8] Wald, G., and Burg, S. P., *J. Gen. Physiol.*, **40**, 609 (1957).
[9] Cawley, J. D., Robeson, C. D., Weisler, L., Shantz, E. M., Embree, N. D., and Baxter, J. G., *Science*, **107**, 346 (1948).
[10] Fisher, L. R., Kon, S. K., and Thompson, S. Y., *J. Marine Biol. Assoc., U.K.*, **31**, 229 (1952).
[11] Fisher, L. R., Kon, S. K., and Thompson, S. Y., *J. Marine Biol. Assoc., U.K.*, **33**, 589 (1954).
[12] Fisher, L. R., Kon, S. K., and Thompson, S. Y., *J. Marine Biol. Assoc., U.K.*, **34**, 81 (1955).
[13] Fisher, L. R., Kon, S. K., and Thompson, S. Y., *J. Marine Biol. Assoc., U.K.*, **36**, 501 (1957).
[14] Fisher, L. R., Kon, S. K., and Thompson, S. Y., *Bull. Inst. Océanog.*, **50**, 1 (1953).

CONTRACTION OF SMOOTH MUSCLES IN NON-IONIC SOLUTIONS

By ROSELYN L. KOLODNY and Prof. W. G. VAN DER KLOOT

Department of Pharmacology, New York University School of Medicine

IT is generally assumed that muscular contraction and electrical activity depend on the presence of an extra-cellular fluid containing the ions of Ringer's solution or one of its variants. However, I. Singh *et al.*[1-3] have repeatedly reported that smooth muscles from the stomach of the frog continue to contract and to conduct action potentials when soaked in sucrose solutions. These experiments are often disregarded. Only recently, Bozler[4] confirmed the report that smooth muscles soaked in sucrose containing calcium chloride retain the ability to contract. We have repeated some of Singh's other experiments and are also able to duplicate his results.

In most of our experiments the smooth muscle of the stomach of the frog, *Rana pipiens*, was used. Strips of the stomach muscle were fastened with one end tied to a strain gauge for recording isometric tension and suspended in a simple bath. The observations were made at room temperatures. The muscles were immersed in a 0·12 *M* sucrose solution, which has about half of the tonicity of normal frog Ringer's. The sucrose was dissolved in distilled water which had been passed afterwards through a demineralizing column. The first response by the muscle to the sucrose medium is a series of large contractions. The spontaneous contractions gradually die out while the muscle undergoes a slow increase in tone. After about 2 hr. in sucrose, the muscle rarely contracts spontaneously, but contractions can be readily elicited by stimulation with $2{\cdot}9 \times 10^{-4}$ *M* epinephrine, as shown in Fig. 1*A* or with $2{\cdot}2 \times 10^{-4}$ *M* acetylcholine. The muscles continue to respond to stimulation for as long as 24 hr. after immersion in 0·12 *M* sucrose.

Muscles soaked for hours in sucrose also retain excitability to electrical stimulation. The responses fall into two general catagories. With some preparations, there is a rapid increase in the tension exerted by the muscle as soon as a d.c. stimulating current (0·05–0·6 m. amp.) begins to flow through the muscle bath; when the stimulating current is turned off, the muscle relaxes to the pre-stimulus tension. With other muscles, under the same conditions, there is little change in the tension exerted by the muscle as long as the stimulating current is flowing. But once the stimulus is turned

off, there is a brief latent period and then the muscle contracts, reaches a maximum tension, and relaxes. The longer the stimulus, the shorter the latent period and the greater the contraction. The variables determining whether the muscle contracts along with, or after, electrical stimulation have not yet been resolved; perhaps the most important factor is the portion of the stomach selected as the source of the muscle strip.

In a smaller series of experiments, it was found that short lengths of the taenia coli of the guinea pig soaked for hours in 0·16 *M* sucrose remain responsive to chemical and electrical stimulation.

Singh and Acharya also reported that sucrose-soaked frog stomach muscle continues to conduct action potentials, judging from an extra-cellular recording. We have taken strips of frog stomach muscle soaked in 0·12 *M* sucrose and simultaneously recorded tension, with a strain gauge, and electrical activity between a pair of fine platinum electrodes pushed into the muscle. As shown in Fig. 1*B*, the contractions of the muscle were accompanied by a marked increase in the amount of electrical activity recorded from the muscle.

We have also begun to study conduction in isolated ureters from the guinea pig, which are ideally suited for measurements of conduction velocities. At 33° C. in Tyrode's solution the conduction velocity is about 2·5 cm./sec. After 220 min. in 0·32 *M* sucrose, the conduction velocity falls to 0·026 cm./sec., probably because the resistance of the extra-cellular fluid has markedly increased.

In a final series of experiments, fine capillary electrodes filled with 3 *M* potassium chloride were thrust into strips of frog stomach muscle which had been soaked in 0·12 *M* sucrose for 3 or more hours. The records are poor technically, owing to the high resistance of the sugar solution and of the micro-electrodes. It is striking, however, how similar the records from sucrose-soaked muscles are to those from muscles in Ringer's solution. Estimates of the 'resting' potentials are uncertain because high tip

Fig. 2. A recording made with a micropipette inserted into a strip of frog stomach muscle soaked for 3 hr. in 0·12 *M* sucrose. The base line is marred by a high noise-level. Calibrations: time, 0·1 sec.; voltage, 50 mV.

potentials are common and uncertain with such fine electrodes. The recorded values ranged between 20 and 70 mV., inside the cell negative. A section of a record is shown as Fig. 2. In only one case was a spike recorded which seemed to overshoot the zero potential baseline. Therefore, it cannot be definitely decided whether or not an action potential can overshoot when the external medium is a sucrose solution. Preliminary results show that in sucrose-soaked muscles treated with epinephrine there is an increase in the rate of spiking and a decrease in the 'resting' potential. Spiking was reversibly eliminated by chilling the sucrose solution bathing the muscle.

The principal conclusion is that the mechanical and electrical behaviour of these smooth muscles are changed relatively little when the tissue is transferred from an environment of Ringer's to a sucrose solution which is about half isotonic. This is true in spite of the change in the extra-cellular fluid and a drastic change in the inorganic composition of the tissue. In sucrose-soaked muscles, ashed and analysed by flame photometry, the concentration of sodium is about 4·5 m*M*/kgm. of muscle water and the concentration of potassium is about 45·7 m*M*/kgm. The values for the Ringer's-soaked muscles are: sodium, 66 m*M*/kgm.; potassium, 129 m*M*/kgm. (ref. 5).

Obviously these results challenge some of the present ideas about the electrical activity and the contraction of smooth muscles. Since the sodium concentration of the muscles falls during the soaking in sucrose to about 10 per cent of the initial value, there is little possibility that the extra-cellular fluid is protected by a diffusion barrier from exchanging with the external medium. Therefore, whatever ions are present in the extra-cellular fluid of a muscle soaked in sucrose must come from the impurities in the reagent grade sucrose, from the distilled and demineralized water, or by leaching from the muscle cells. Although we cannot as yet place a precise upper limit on the concentration of ions in the extra-cellular fluid of the sucrose-soaked muscles, it must be extremely low compared with the normal environment of the cells. Holman[6] showed that the electrical activity of smooth muscles does not depend on the sodium concentration of the external medium in the way that is familiar with nerve and with skeletal muscle. However, it is still surprising to see electrical signals which look very similar to the normal action potentials occurring when the extra-cellular fluid can contain only a fraction of a millimole of sodium.

The continued contraction by sucrose-soaked smooth muscles is equally surprising. Axelsson and

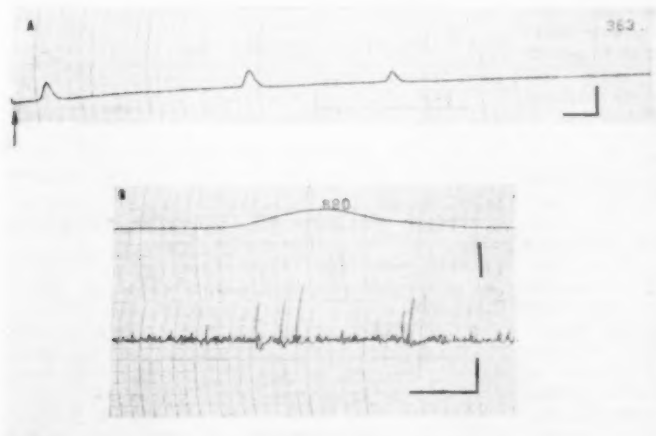


Fig. 1. *A*, response of a strip of frog stomach muscle, soaked for 3½ hr. in 0·12 *M* sucrose, to epinephrine hydrochloride (added at the arrow). Note the increase in tone and the three rhythmic contractions. Calibrations: time, 30 sec.; tension, 0·5 gm. *B*, simultaneous electrical and mechanical recordings from a strip of frog stomach muscle soaked for 3 hr. in 0·12 *M* sucrose. The record shows a spontaneous contraction and the simultaneous electrical activity. Calibrations: time, 30 sec.; tension, 0·5 gm.; voltage, 50 μV.

Bulbring[7] showed that the removal of calcium from Ringer's solution led to the loss of tension by the taenia coli, and Robertson[8] showed that the mechanical response of smooth muscles (depolarized in potassium sulphate-Ringer's and stimulated with acetylcholine) declined markedly when calcium was withdrawn from the medium. These experiments were interpreted as showing that extra-cellular calcium is needed for contraction. The concentration of calcium in the extra-cellular fluid is unlikely to be markedly greater in a muscle soaked for many hours in 0·12 *M* sucrose than in a muscle soaked for a shorter time in a calcium-free Ringer's. Nevertheless, the sucrose-soaked muscles can contract. It appears that ionic solutions which do not contain calcium may stop smooth muscles from contracting—perhaps by displacing a critical fraction of the calcium from the cell. However, from the evidence now at hand it cannot be concluded that the contraction of smooth muscles depends on the presence of calcium in the extra-cellular fluid.

It is also remarkable to find continued electrical and mechanical activity, supported by the metabolism of the cells, coming from a tissue the intracellular ionic composition of which must be changed so drastically.

In summary, we have confirmed the observations by Singh *et al.* that smooth muscles soaked in half-isotonic sucrose solutions retain electrical activity and contractility. The behaviour of 'slow' skeletal muscle fibres in sucrose is different from that of smooth muscles; acetylcholine, which normally produces depolarization and contraction, causes sucrose-soaked frog recti to become hyperpolarized and to relax[9].

This investigation was supported by Public Health Service Research Grant *B*-1870 from the Institute of Neurological Diseases and Blindness, U.S. Public Health Service.

[1] Singh, I., and Singh, I., *Proc. Indian Acad. Sci.*, **18**, 58 (1943).
[2] Singh, I., and Bhatt, J. V., *Proc. Indian Acad. Sci.*, **65**, 64 (1957).
[3] Singh, I., and Acharya, A. K., *Proc. Indian Acad. Sci.*, **46**, 285 (1957).
[4] Bozler, E., *Amer. J. Physiol.*, **199**, 299 (1960).
[5] Bozler, E., Calvin, M. E., and Watson, D. W., *Amer. J. Physiol.*, **195**, 38 (1958).
[6] Holman, M. E., *J. Physiol.*, **141**, 464 (1958).
[7] Axelsson, J., and Bülbring, E., *J. Physiol.*, **149**, 50*P* (1959).
[8] Robertson, P. A., *Nature*, **186**, 316 (1960).
[9] Swift, M. R., Gordon, H. P., and Van der Kloot, W. G., *Proc. U.S. Nat. Acad. Sci.*, **46**, 1415 (1960).

MOVEMENT OF THE OVUM IN THE REPRODUCTIVE TRACT

A Needle Probe Geiger-Müller Counter for the Study of the Passage of the Ovum in the Reproductive Tract

IN an endeavour to inquire into the reasons for the failure of non-surgical transfers of ova into recipient cows[1], small radioactive spheres[2], the passage of which in the reproductive tract could be traced with a newly designed probe unit, were used to simulate cow ova. The 'artificial ova', consisting of an ion exchange resin ('Permutit'), impregnated with radioactive gold, gold-198, of density 1·2 and 120μ in diameter, were transferred to the cow uterus via the cervix. They were suspended in a small quantity of cow serum delivered from a syringe attached to a narrow metal tube extending into the uterine horn. The needle probe apparatus was then used to search the internal walls of the uterine horns, cervix and vagina for the presence of the radioactive artificial ova at varying intervals of time after transfer. A report of the results of this investigation forms the subject of the next communication. The gold-198 spheres are also being used in some other work on the tubal transport of ova in the rabbit[3] and in the ewe[4].

The essential part of the needle probe apparatus (Fig. 1) is the stainless steel *N1b* needle counter (20th Century Electronics), contained in a chromium plated counter holder. The needle counter itself is 150 mm. long and the active length of the Geiger–Müller counter is 12 mm., situated 7 mm. from the tip of the needle. The probe assembly consists of the counter holder bolted on to a hollow polythene guide of length 58 mm. and outside diameter 34 mm., utilizing the earthing nut at the rear of the holder. Into this guide is inserted a thin-walled aluminium metal tube of 25 mm. outside diameter. A further polythene guide 15 mm. long is situated 5 cm. behind the first. The rear part of the aluminium tube is covered with a rubber sheath handle, through which the high-tension cable passes out to a rate-meter which measures any radioactivity detected. The whole of the probe assembly as shown in Fig. 1 is inserted into a chromium plated probe sheath 34 cm. long with an outside diameter of 3·8 cm. Part of the probe sheath consists of a detachable blunt-ended needle guide, 12·5 cm. long and 4·0 mm. outside diameter, screwed on to the end. The needle of the counter is directed into the needle guide by means of three centralizing lugs on the counter holder, and by the polythene guides on the probe assembly.

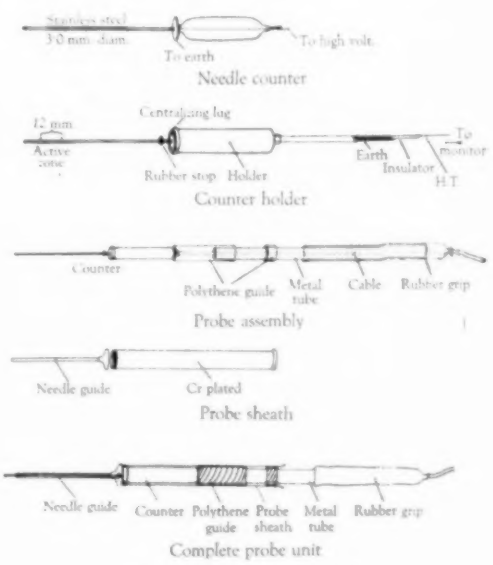


Fig. 1. Needle probe equipment

In order to search the cow reproductive tract for any radioactivity emitted from the gold-198 spheres, the complete probe unit (Fig. 1) is grasped in one hand by means of the rubber handle of the probe assembly. The other hand is inserted into the rectum of the cow to help guide the needle through the cervix and into the uterine horns. A little 'Vaseline' on the outside of the probe sheath is sometimes needed to ease the probe sheath up the vaginal tract. With the needle retracted into the needle guide, the complete probe unit is inserted and the needle guide passed through the cervix into the uterus of the cow. The counter is then eased forward up the probe sheath by applying forward pressure on the rubber grip with the free hand. The needle slides out from the guide, exposing the active counting zone to any radiation present in the near vicinity. The intensity of radiation present is measured on the rate-meter. It was found possible to estimate very rapidly the approximate number of gold-198 spheres in the uterus or the vagina merely by judging the noise emitted by the loudspeaker in the rate-meter. The vagina was always searched for radioactivity before investigating the cervix and uterus. This ensured that any radioactivity detected in the vagina was not due to gold-198 spheres which might be dislodged from the uterus during manipulation of the needle guide through the cervix.

In withdrawing the probe unit, the needle is retracted into the needle guide by pulling on the rubber grip, two marks on the aluminium tube indicating full extension and full retraction of the needle. The probe sheath is then drawn slowly back to the exterior. By repeating the procedure described, the counter may be used to search the walls of the uterus, cervix and vagina and the external organs of reproduction. If a sharp-pointed needle guide is attached to the probe sheath in place of the blunt-ended one, then such a point can be used to pierce the wall of the vagina, and search for activity in the Fallopian tubes or ovaries or in the abdominal cavity.

Acknowledgment is due to Dr. J. C. Boursnell for his helpful interest and advice.

J. P. BENNETT

[1] Dowling, D. F., *J. Agric. Sci.*, **39**, 374 (1949). Rowson, L. E. A., *J. Endocrin.*, **7**, 260 (1951). Umbaugh, R. E., *Fertil. and Steril.*, **2**, 243 (1951). Dracy, A. E., *Iowa State Coll. J. Sci.*, **28**, 101 (1953). Dzink, P. J., and Petersen, W. E., *J. Animal Sci.*, **13**, 1019 (1954). Rowson, L. E. A. (unpublished results).

[2] Harper, M. J. K., Bennett, J. P., Boursnell, J. C., and Rowson, L. E. A., *J. Reprod. Fertil.*, **1**, 249 (1960).

[3] Bennett, J. P., and Rowson, L. E. A., *Fourth Int. Congr. Anim. Reprod.* (in the press).

A Possible Explanation for the Failure of Non-Surgical Ovum Transfers in the Cow

SURGICAL transfer of fertilized ova by puncture of the uterine wall has been successful in several mammalian species including the cow[1], but the non-surgical approach through the cervix has so far been successful only in the mouse[2]. In the rabbit, transfer of the ovum through the cervix has also been successful, but it involved a surgical incision in the vagina[3]. In the cow many attempts have been made to obtain pregnancies by the non-surgical transfer of ova through the cervix, but all have been unsuccessful[4]. Work on cows, however, has shown that stimulation of the cervix causes the release of oxytocin, thus increasing uterine contractions, and that an injection of oxytocin induces uterine contractions at all stages of the oestrous cycle[5].

The experiments reported here were designed to throw some light on the problems involved in the non-surgical transfer of ova to the cow. It was felt that such a transfer, which is carried out in the early luteal phase of the cycle owing to the necessity of synchronizing the development of the ovum with that of the uterine endometrium, might stimulate the cervix, release oxytocin, and produce uterine contractions, as a result of which the ova would be either expelled into the vagina or driven towards the utero-tubal junction. The technique employed depended on the use of 'artificial ova', consisting of resin spheres impregnated with radioactive gold[6]. Between 10 and 30 such spheres were transferred, in 0·75–1·0 c.c. of sterile homologous blood serum, non-surgically through the cervix of recipient heifers about three days after oestrus, using a stainless steel catheter of external diameter 1·5 mm. and length 40 cm. connected to a 5-c.c. syringe by a 15-cm. length of polythene tubing (external diameter 2·25 mm.). It was hoped that by using such a fine catheter for the transfer, stimulation of the cervix would be reduced to a minimum. At varying times after the insertion of the spheres the uterus, cervix and vagina were checked for radioactivity with a needle-probe Geiger counter, which is described in the previous communication.

It was found (Table 1) that, 1¼–1½ hr. after transfer, the spheres started to move through the cervix, and that after 1½ hr. a large proportion of the spheres had been expelled from the uterus altogether. In exp. 7 (Table 1) 11 out of 25 spheres were recovered from the vagina 4¼ hr. after insertion. In two animals examined (exp. 8 and 9), 20¼ hr. after insertion, some spheres had already been voided from the vagina and consequently little or no radioactivity could be demonstrated in the vagina, whereas some other spheres were still retained by the uterus. In another animal (exp. 10) the spheres were transferred surgically, and these, too, were found in the vagina 4¾ hr. later, probably as a result of the traction applied to the uterus during the laparotomy, which may have been quite sufficient to cause the release of oxytocin.

In another group of four experiments (Table 2), cow ova were transferred non-surgically to recipient heifers, and at varying intervals after the transfer the animals were slaughtered, and the reproductive tracts searched for the ova. Of the 37 ova transferred,

Table 1. FATE OF RADIOACTIVE SPHERES TRANSFERRED NON-SURGICALLY TO THE UTERUS OF HEIFERS 3–3¼ DAYS AFTER OESTRUS

Exp. No.	Time from insertion of spheres to checking for activity (hr.)	Portions of the reproductive tract checked				
		Vagina		Cervix	Uterus	
		Posterior	Anterior		Near cervix	Cornua†
1	¼	–	–	N.C.	N.C.	N.C.
2	1¼	–	–	+	N.C.	N.C.
3	1½	–	+ + +	–	–	–
4	1¾	–	+ + +	–	+ + +	–
5	1¾	–	+ + +	–	+ + +	+ +
6	3¼	+ + +	+ +	–	–	–
7*	4¼	+ +	+	–	+ + +	–
8	20¼	–	–	–	+ +	–
9	20¼	–	+	–	+ + +	–
Surgical transfers						
10	4¾	+ + +	–	–	–	–

* Eleven out of twenty-five radioactive spheres transferred were recovered from the vagina.

† Site of deposition was about half-way up the uterine horn.

Scale of radioactivity: N.C., not checked; + + +, very active; + +, active; +, slightly active; –, not active.

A Possible Explanation for the Failure of Non-Surgical Ovum Transfers in the Cow

SURGICAL transfer of fertilized ova by puncture of the uterine wall has been successful in several mammalian species including the cow[1], but the non-surgical approach through the cervix has so far been successful only in the mouse[2]. In the rabbit, transfer of the ovum through the cervix has also been successful, but it involved a surgical incision in the vagina[3]. In the cow many attempts have been made to obtain pregnancies by the non-surgical transfer of ova through the cervix, but all have been unsuccessful[4]. Work on cows, however, has shown that stimulation of the cervix causes the release of oxytocin, thus increasing uterine contractions, and that an injection of oxytocin induces uterine contractions at all stages of the oestrous cycle[5].

The experiments reported here were designed to throw some light on the problems involved in the non-surgical transfer of ova to the cow. It was felt that such a transfer, which is carried out in the early luteal phase of the cycle owing to the necessity of synchronizing the development of the ovum with that of the uterine endometrium, might stimulate the cervix, release oxytocin, and produce uterine contractions, as a result of which the ova would be either expelled into the vagina or driven towards the utero-tubal junction. The technique employed depended on the use of 'artificial ova', consisting of resin spheres impregnated with radioactive gold[6]. Between 10 and 30 such spheres were transferred, in 0·75–1·0 c.c. of sterile homologous blood serum, non-surgically through the cervix of recipient heifers about three days after oestrus, using a stainless steel catheter of external diameter 1·5 mm. and length 40 cm. connected to a 5-c.c. syringe by a 15-cm. length of polythene tubing (external diameter 2·25 mm.). It was hoped that by using such a fine catheter for the transfer, stimulation of the cervix would be reduced to a minimum. At varying times after the insertion of the spheres the uterus, cervix and vagina were checked for radioactivity with a needle-probe Geiger counter, which is described in the previous communication.

It was found (Table 1) that, 1¼–1½ hr. after transfer, the spheres started to move through the cervix, and that after 1½ hr. a large proportion of the spheres had been expelled from the uterus altogether. In exp. 7 (Table 1) 11 out of 25 spheres were recovered from the vagina 4¼ hr. after insertion. In two animals examined (exp. 8 and 9), 20¼ hr. after insertion, some spheres had already been voided from the vagina and consequently little or no radioactivity could be demonstrated in the vagina, whereas some other spheres were still retained by the uterus. In another animal (exp. 10) the spheres were transferred surgically, and these, too, were found in the vagina 4¾ hr. later, probably as a result of the traction applied to the uterus during the laparotomy, which may have been quite sufficient to cause the release of oxytocin.

In another group of four experiments (Table 2), cow ova were transferred non-surgically to recipient heifers, and at varying intervals after the transfer the animals were slaughtered, and the reproductive tracts searched for the ova. Of the 37 ova transferred,

Table 2. Fate of Cow Ova Transferred Non-surgically into the Uterus of Recipient Heifers

Exp. No.	Days from œstrus to transfer	Ova transferred (No.)	Time from insertion to autopsy (hr.)	Ova recovered in: vagina	uterus	cervix	Recipient's own ovum recovered from the Fallopian tube
11	3	7	1½	1	0	2	+
12	3	8	2	1	0	0	+
13	3	11	3	4	0	3	+
14	9	11	2½	0	8	0	−
	Total	37	Total	6	8	5 = 19 (51·4 per cent)	

only 19 (51·4 per cent) were recovered. Some of the ova were expelled into the vagina just as rapidly as the radioactive spheres, but it is possible that at the peak of the luteal phase (exp. 14) expulsion is slower than during its early stage (exp. 1–13); during œstrus, expulsion occurs even more rapidly. Altogether, our results show that the radioactive 'artificial ova' do in fact behave in a similar manner to normal ova.

Preliminary attempts to block the ejection mechanism by the injection of adrenaline have been so far unsuccessful. This does not necessarily mean that the factor causing the ejection is not oxytocin, since the action of adrenaline is known to be a transient one, only blocking uterine activity for 4–8 min.[5d]. Spinal anæsthetics sufficient to paralyse the whole hind quarters of the cows were also tried, but again the spheres were ejected as in the untreated cows.

From the observations reported in this communication it is concluded that one of the reasons for the failure of non-surgical ovum transfers in the cow is the ejection of the ova about 1½ hr. after insertion. This may be due to stimulation of the cervix at the time of the transfer, which causes the release of oxytocin from the pituitary gland, and consequently uterine contractions.

We are grateful to Dr. T. R. R. Mann for discussing this manuscript. We acknowledge generous financial assistance from the Milk Marketing Board, and one of us (M. J. K. H.) acknowledges the receipt of an Agricultural Research Council Postgraduate Studentship.

M. J. K. Harper
J. P. Bennett
L. E. A. Rowson

Agricultural Research Council Unit of Reproductive Physiology and Biochemistry, Animal Research Station, University of Cambridge.

[1] Willett, E. L., Black, W. G., Casida, L. E., Stone, W. H., and Buckner, P. J., *Science*, **113**, 247 (1951). Willett, E. L., Buckner, P. J., and Larson, G. L., *J. Dairy Sci.*, **36**, 520 (1953).

[2] Beatty, R. A., *Nature*, **168**, 995 (1951). Tarkowski, A. K., *Acta theriol.*, **2**, 251 (1599).

[3] Adams, C. E., *J. Endocrin.*, **13**, 296 (1956). Shah, M. K., *Nature*, **177**, 1134 (1956).

[4] Dowling, D. F., *J. Agric. Sci.*, **39**, 374 (1949). Umbaugh, R. E., *Fertil. and Steril.*, **2**, 243 (1951). Rowson, L. E. A., *J. Endocrin.*, **7**, 260 (1951). Dracy, A. E., *Iowa State Coll. J. Sci.*, **28**, 101 (1953). Dziuk, P. J., and Petersen, W. E., *J. Anim. Sci.*, **13**, 1019 (1954). Rowson, L. E. A. (unpublished results).

[5] (*a*) Vandemark, N. L., and Hays, R. L., *J. Anim. Sci.*, **10**, 1083 (1951); (*b*) *Amer. J. Physiol.*, **170**, 518 (1952). (*c*) Hays, R. L., and Vandemark, N. L., *Endocrin.*, **52**, 634 (1953); (*d*) *Amer. J. Physiol.*, **172**, 557 (1953).

[6] Harper, M. J. K., Bennett, J. P., Boursnell, J. C., and Rowson, L. E. A., *J. Reprod. Fertil.*, **1**, 249 (1960).

COPRECIPITATION OF MITOCHONDRIA AND CHLOROPLASTS

By RACHEL M. LEECH
Department of Botany
AND
Dr. R. J. ELLIS
Agricultural Research Council Unit of Plant Physiology, Imperial College of Science and Technology, London, S.W.7

TO obtain critical evidence for the presence of an enzyme or multi-enzyme system in a particular cell organelle, it is necessary to prepare this organelle free from all other types of sub-cellular particle. In the case of isolated chloroplasts, differential centrifugation is the method generally employed in attempts to free chloroplasts from smaller particles. Since 1956, many workers have followed the procedure of Arnon *et al.*[1] in which the chloroplasts are sedimented from the leaf homogenates at 1,000*g* after removal of debris and whole cells. Resuspension of the chloroplast pellet, followed by centrifuging at 1,000*g*, has been commonly employed with the view of removing residual amounts of smaller particles[1–3].

However, the absence of biochemically active mitochondria from these preparations has usually been assumed rather than demonstrated. With the advent of a technique for separating chloroplasts from contaminating mitochondria by centrifugation in a density gradient[4], it has been shown that *Vicia faba* chloroplasts, prepared by the usual method[1] and twice washed, are still accompanied by numerous mitochondria. The aim of the present work was to determine how far the presence of mitochondria in chloroplast preparations can account for one of the features attributed to the plastids, namely, the presence of glutamic–oxaloacetic transaminase.

Aspartate is one of the compounds labelled when isolated spinach chloroplasts fix $^{14}CO_2$ in the light[5,6], while the addition of phosphoenolpyruvate and $^{14}CO_2$ to a water extract of spinach chloroplasts leads to the formation of labelled oxaloacetate and labelled aspartate[7]. Although mitochondria from leaves have not been extensively studied in this respect, glutamic–oxaloacetic transaminase has been shown to be present in mitochondria from a number of higher plant sources[8–11]. In view of these findings, the assumption that the formation of aspartate is an aspect of chloroplast metabolism[7] has been further investigated.

Chloroplasts and mitochondria were isolated from leaves just fully expanded of *Vicia faba* plants 2–3

Fig. 1. Assay of transaminases by paper chromatography. Pellets of unpurified chloroplasts (*a*), mitochondria (*b*), purified chloroplasts (*c*), and a mixture of mitochondria and purified chloroplasts spun at 1,000*g* for 12 min. (*d*), were washed once in sucrose–phosphate medium and taken up in 6 ml. distilled water. Samples (2 ml.) were incubated with α-ketoglutarate (75 μmoles) and either DL-aspartate (150 μmoles) or L-alanine (50 μmoles) in a total volume of 3 ml. phosphate buffer (0·067 *M*, *p*H 7·3) for 4 hr. at 30°. The ethanol-soluble material was chromatogrammed in phenol. *M*, marker glutamate; *A*, aspartate + α-ketoglutarate, zero time; *B*, aspartate + α-ketoglutarate, 4 hr.; *C*, alanine + α-ketoglutarate, zero time; *D*, alanine + α-ketoglutarate, 4 hr.; *E*, α-ketoglutarate, 4 hr.

weeks old. The procedure of James and Das was employed[8], except that the leaves were ground by hand in sucrose (0·3 *M*) containing phosphate buffer (0·067 *M*, *p*H 7·3). Mitochondrial and crude chloroplast preparations were obtained from the same homogenate. The crude chloroplast preparations were then purified by centrifugation in a sucrose–glycerol density gradient. Purified chloroplasts were disintegrated at 2° C. by ultrasonic vibration and the green fragments ('grana') separated from the straw-coloured supernatant solution ('stroma') by centrifuging at 105,000*g* for 30 min. Water extracts were prepared by adding small volumes (5–6 ml.) of ice-cold distilled water or dilute phosphate buffer to the mitochondrial and chloroplast pellets; after 30 min. the particulate material was centrifuged down and the clear solution decanted. Glutamic–oxaloacetic transaminase and glutamic–pyruvic transaminase were detected qualitatively by the chromatographic separation of amino-acids present in reaction mixtures; glutamic–oxaloacetic transaminase was assayed quantitatively in water extracts by the spectrophotometric measurement of oxaloacetate at 280 mμ[12].

Crude chloroplast preparations were found by chromatography to contain the two transaminases (Fig. 1*a*); the glutamic–oxaloacetic transaminase was also detected in water extracts of crude chloroplast preparations, confirming previous results[7]. However, mitochondrial preparations obtained from the same homogenates as were used for the isolation of chloroplasts also contained both transaminases (Fig. 1*b*). The purified chloroplasts were next examined; on four occasions, no transaminase activity could be demonstrated by the chromatographic method in either intact chloroplasts (Fig. 1*c*) or the 'grana' or 'stroma' fractions prepared from these chloroplasts. In addition, glutamic–oxaloacetic transaminase could not be detected by the spectrophotometric method either in the 'stroma' or in water extracts of whole chloroplasts. Chloroplast suspensions containing as much as 2·5 mgm. chlorophyll or the 'stroma' obtained from chloroplasts equivalent to 4 mgm. chlorophyll were used in the reaction mixtures (final vol., 3 ml.). The addition of pyridoxal 5-phosphate ($0{\cdot}75 \times 10^{-4}$ *M*) had no effect.

From these results it seemed possible that the transaminase activity of the crude chloroplast preparations could be attributed to the presence of mitochondria. An experiment was therefore designed to test the possibility that mitochondria are co-precipitated with chloroplasts. Mitochondria and purified chloroplasts were prepared from bean leaves (fresh weight 325 gm.) and suspended in sucrose–phosphate medium. Increasing volumes of the mitochondrial suspension were added to a constant volume of the chloroplast suspension, and the mixtures centrifuged at 1,000*g* for 12 min. The pellets were washed once in 10 ml. of medium and resuspended in 5 ml. phosphate buffer (0·005 *M*, *p*H 7·3). After 30 min. at 2° C., the suspensions were centrifuged at 17,000*g* for 45 min., and the clear supernatant solutions assayed for glutamic–oxaloacetic transaminase by the spectrophotometric method. The results (Table 1) show that a linear relationship exists between the amount of transaminase and the volume of mitochondrial suspension added to the purified chloroplasts. The contamination of the chloroplast pellets by mitochondria as shown by the presence of the transaminases was confirmed by the chromatographic method (Fig. 1*d*). Mitochondria were observed microscopically in washed pellets from tubes *B*–*G*, but were absent from tube *A* (Table 1).

In view of the assumption that washing removes the mitochondria, the effect of washing a mixture of purified chloroplasts and mitochondria was studied. Fig. 2 shows that the first wash removes a considerable fraction of the transaminase activity, but that additional washing has little further effect.

These experiments clearly demonstrate that mitochondria sediment with chloroplasts when suspensions containing both types of particle are spun at 'chloroplast' speed (1,000*g*), and that these mitochondria are not completely removed by two washings. The possibility must therefore be considered that mitochondrial contamination is responsible for some of the properties of chloroplasts isolated by procedures involving only differential centrifugation. It is

Table 1. Coprecipitation of Mitochondria and Chloroplasts

Contents of centrifuge tubes	Units of Transaminase
A. 5 ml. Ch. + 5 ml. medium	0·0
B. 5 ml. Ch. + 0·5 ml. M. + 4·5 ml. medium	0·53
C. 5 ml. Ch. + 1·0 ml. M. + 4 ml. medium	1·87
D. 5 ml. Ch. + 2·0 ml. M. + 3 ml. medium	3·25
E. 5 ml. Ch. + 3·0 ml. M. + 2 ml. medium	4·44
F. 5 ml. Ch. + 5·0 ml. M.	8·7
G. 1 ml. M. + 9·0 ml. medium	3·06

M., mitochondrial suspension; Ch., purified chloroplast suspension. Medium: sucrose (0·3 *M*) containing phosphate buffer (0·067 *M*, *p*H 7·3).

Tubes *A*–*F* were centrifuged at 1,000*g* for 12 min.; tube *G* was centrifuged at 17,000*g* for 20 min. The pellets were washed once with sucrose–phosphate medium before water extracts were made. The extracts were assayed at 20° for glutamic–oxaloacetic transaminase (ref. 12). Units as defined by Ellis and Davies (ref. 12).

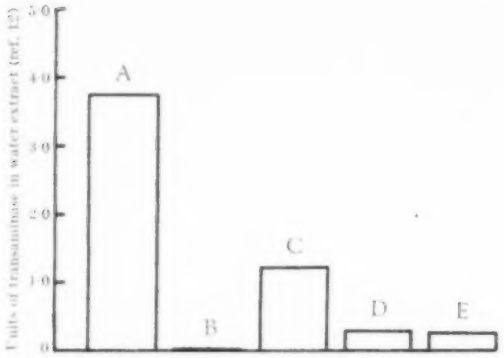


Fig. 2. Effect of washing on mitochondrial contamination. *A*, 5 ml. M. + 5 ml. medium, centrifuged at 17,000*g* for 20 min.; *B*, 5 ml. Ch. + 5 ml. medium, centrifuged at 1,000*g* for 12 min.; *C*, 5 ml. Ch. + 5 ml. M., centrifuged at 1,000*g* for 12 min.; *D*, as *C*, but washed once in 10 ml. medium; *E*, as *C*, but washed twice in 10 ml. medium.
Water extracts were made from all the final pellets, and assayed for glutamic-oxaloacetic transaminase (ref. 12).
M., mitochondrial suspension; Ch., purified chloroplast suspension; both in sucrose–phosphate medium

suggested that the amount of glutamic–oxaloacetic transaminase could be used as an index of the degree of contamination of chloroplast preparations by mitochondria. As we have found that the purified chloroplasts, as well as the mitochondria, contain highly active malic dehydrogenase[12], the sensitivity of the transaminase assay could be increased considerably by linking the production of oxaloacetate with the oxidation of reduced diphosphopyridine nucleotide[14].

The possibility cannot be ruled out that purification by the glycerol technique completely removes transaminases from the chloroplasts. Zelitch and Barber have found that high concentrations of glycerol reduce, but do not eliminate, the oxidative activity of spinach mitochondria[15]. The glutamic–oxaloacetic transaminase activity of water extracts of bean leaf mitochondria is also reduced (by about 50 per cent) by pretreatment of the mitochondria with 60 per cent glycerol[12]. In neither case does the glycerol treatment result in a complete disappearance of enzymic activity. The chloroplasts purified by the glycerol technique are not devoid of enzymes; they are able to carry out the complete process of photophosphorylation, and contain triphosphopyridine nucleotide-triose phosphate dehydrogenase and malic dehydrogenase[16]. In addition, chloroplasts freed from mitochondria by an alternative technique (centrifuging in a sucrose–diodone density gradient[4]) do not contain any glutamic–oxaloacetic transaminase but still exhibit triphosphopyridine nucleotide-triose phosphate dehydrogenase and malic dehydrogenase activity. The available evidence, therefore, suggests that the absence of transaminases from the purified chloroplasts is not a result of the purification procedure. In any event, the great advantage of working with chloroplasts free from mitochondria must be weighed against any possible disadvantage associated with the purification procedure.

[1] Arnon, D. I., Allen, M. B., and Whatley, F. R., *Biochim. Biophys. Acta*, **20**, 449 (1956).
[2] Sissakian, N. M., *Adv. in Enzymol.*, **20**, 201 (1958).
[3] Jagendorf, A. T., and Wildman, S. G., *Plant Physiol.*, **29**, 270 (1954).
[4] James, W. O., and Das, V. S. R., *New Phyt.*, **56**, 325 (1957).
[5] Allen, M. B., Arnon, D. I., Capindale, J. B., Whatley, F. R., and Durham, L. J., *J. Amer. Chem. Soc.*, **77**, 4149 (1954).
[6] Holm-Hansen, O., Pon, N. G., Nishida, K., Moses, V., and Calvin, M., *Physiol. Plantarum*, **12**, 475 (1959).
[7] Rosenberg, L. L., Capindale, J. B., and Whatley, F. R., *Nature*, **181**, 632 (1958).
[8] Ellis, R. J., Ph.D. thesis, University of London (1960).
[9] Wilson, D. G., King, K. W., and Burris, R. H., *J. Biol. Chem.*, **208**, 863 (1954).
[10] Leonard, M. J. K., and Burris, R. H., *J. Biol. Chem.*, **170**, 701 (1947).
[11] Bone, D. H., and Fowden, L., *J. Exp. Bot.*, **11**, 104 (1960).
[12] Ellis, R. J., and Davies, D. D., *Biochem. J.*, **78**, 615 (1961).
[13] Leech, R. M., and Ellis, R. J. (unpublished results).
[14] Davies, D. D., and Ellis, R. J., *Biochem. J.*, **78**, 623 (1961).
[15] Zelitch, I., and Barber, G. A., *Plant. Physiol.*, **35**, 626 (1960).
[16] James, W. O., and Leech, R. M. (unpublished results).

INDUCTION OF HERITABLE RESPIRATORY DEFICIENCY IN *SACCHAROMYCES* BY PANTOTHENATE STARVATION

By PROF. ALVIN SARACHEK and GREGORY L. FOWLER
Department of Biology, University of Wichita, Kansas

CYTOPLASMICALLY inherited respiratory deficiency in *Saccharomyces* is characterized by the permanent loss or depression of the activities of a number of enzymes structurally associated with the mitochondrion[1]. Though a variety of chemical and physical treatments have been described which induce this condition[2–5], the particular metabolic disturbances which comprise the inducing event are not yet defined. Bearing on this question, we have reported that anaerobically grown yeast cells are more responsive to inducers of respiratory deficiency than cells grown aerobically[6]. Since the terminal electron transport system is inoperative in anaerobically grown cells, it is possible that at least one of the metabolic processes which sustain inducing damage is partially debilitated simply by a limitation of intracellular hydrogen acceptors. The severe reduction of overall lipid synthesis which occurs characteristically when yeasts are grown anaerobically[7] suggested to us that the oxidation of pyruvate to acetate might represent such a process. If this were so, then limiting the ability of cells to generate acetate during aerobic growth on glucose should increase their susceptibilities to induction of respiratory deficiency. To test this possibility we have attempted to prepare acetate-deficient yeasts by both aerobic and anaerobic propagations on a pantothenate-free medium. Growth under these conditions is known to depress cellular coenzyme *A*-levels and result in a consequent depression of both acetate formation and utilization[8]. The present article describes our observations that cells are transformed directly into respiration-deficient mutants when grown aerobically in the absence of pantothenate and that such transformation can be prevented by the provision of exogenous acetate or certain higher fatty acids.

The test organism was a tetraploid strain of *Saccharomyces* possessing absolute and partial growth requirements for adenine and pantothenate respectively. Respiration-deficient mutants of spontaneous origin occur within this strain in a frequency of about 0·3 per cent. The basal pantothenate-free growth medium used was of the following composition: glucose, 40 gm.; ammonium tartrate, 2 gm.; potassium dihydrogen phosphate, 1·5 gm.; dipotassium hydrogen phosphate, 0·3 gm.; crystalline magnesium sulphate, 0·5 gm.; calcium chloride, 0·33 gm.; crystalline ferrous sulphate, 3 mgm.; crystalline zinc sulphate, 3 mgm.; crystalline copper sulphate, 0·5 mgm.; crystalline manganous sulphate, 0·4 mgm.; $(NH_4)_6Mo_7O_{24}.4H_2O$, 0·15 mgm.; $Na_2B_4O_7.10H_2O$, 0·9 mgm.; inositol, 10 mgm.; thiamine hydrochloride, 1 mgm.; *para*aminobenzoic acid, 0·6 mgm.; pyridoxine, 0·6 mgm.; nicotinic acid, 0·6 mgm.; biotin, 0·02 mgm.; adenine sulphate, 150 mgm.; water, 1,000 ml. To prepare pantothenate-supplemented medium, 1 mgm. of calcium pantothenate was added per litre. This as well as other additions to the medium as indicated in the text were made prior to autoclaving at 10 lb. pressure for 10 min. For aerobic growth, the medium was dispensed in 50-ml. quantities into 250-ml. Erlenmeyer flasks; following inoculation the flasks were incubated at 28° C. on a reciprocal shaker operating at 100 2-in. strokes per minute. For anaerobic growth, screw-cap test-tubes 20 cm. × 2 cm. were filled to a depth of about 17 cm. with 50 ml. of medium, inoculated and incubated statically at 28° C. Though these static growth conditions are properly described as micro-aerobic, they are effectively anaerobic since cells so cultivated fail to achieve the enzymatic adaptation to oxygen utilization which occurs under aerobiosis[9]. Cells for experimental inocula were harvested from the log phase of pantothenate-supplemented aerobic cultures, washed four times in *M*/15 potassium dihydrogen phosphate and introduced to a density of about $3·0 \times 10^4$ cells per ml. into the experimental flasks or tubes. At intervals during subsequent incubation 1-ml. samples of the cultures were plated to determine increases in cell numbers and the frequencies of respiratory mutants appearing in the populations. The composition of the plating medium and the technique for scoring respiration-deficient mutants have been described previously[10].

Curves presented in Fig. 1 illustrate the increases in number of cells and the frequencies of respiratory variants scored in cultures prepared as indicated above. It is seen that cells express a partial growth requirement for pantothenate under both aerobic and anaerobic conditions. It may also be noted that in pantothenate-free medium both aerobically and anaerobically cultivated cells show initially rapid, though declining, rates of increase which are stabilized into logarithmic rates of growth approximately 12 hr. after inoculation. Undoubtedly, this anomalous growth behaviour is due to a carry-over of stored pantothenate in the cells of the inoculum. Through the early and middle portions of the logarithmic periods of growth, the frequencies of respiratory variants are maintained at the spontaneous levels in all cultures. However, during the period of transition from the logarithmic into the stationary phase of growth, cells cultivated aerobically in the absence of pantothenate are converted *en masse* into respiration-deficient mutants; no such transformation occurs in either the pantothenate-supplemented culture or in anaerobic cultures with or without pantothenate.

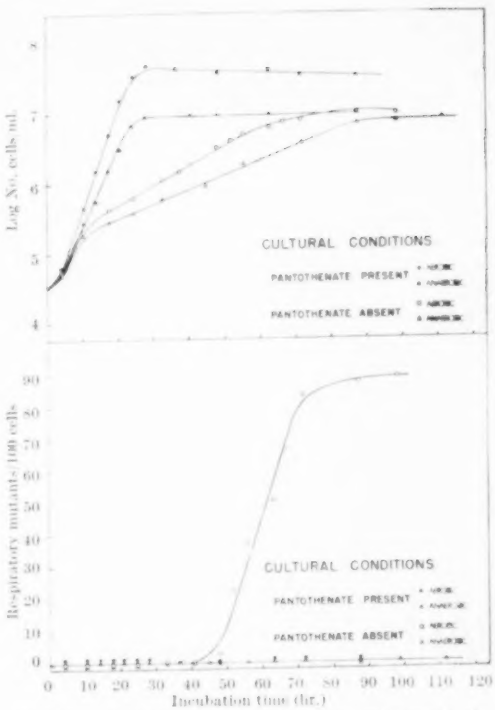


Fig. 1. Growth and mutation curves of cells cultivated aerobically or anaerobically in the presence or absence of pantothenate

To determine what bearing lipid metabolism might have on this mutation, acetate as well as representative sterols and higher saturated and unsaturated fatty acids were tested individually for possible influences on the compositions of early stationary-phase populations attained in pantothenate-free aerobic cultures. The results summarized in Table 1 show that, with the exception of cholesterol, each of the lipids examined increases the total cell yield over that obtained in the absence of lipid. This is consistent with a previous report that pantothenate starvation causes multiple lipid deficiencies in *Saccharomyces*[11]. On the other hand, only acetate and the mono-unsaturated oleic acid appear highly effective in preventing the occurrence of respiratory

Table 1. Effects of Acetate, Higher Fatty Acid and Sterol Supplements on the Total Number of Cells and the Frequencies of Respiration-deficient Mutants produced in Pantothenate-free Cultures after 72 hr. Incubation Cultures were inoculated to an Initial Density of $2·9 \times 10^3$ cells/ml.

	Cell No./ml.	Mutants/100 cells
Supplement*		
None	$7·6 \times 10^6$	86·6
Potassium acetate	$2·4 \times 10^7$	1·7
Unsaturated fatty acids		
Linoleic acid	$1·1 \times 10^7$	81·3
Oleic acid	$2·1 \times 10^7$	1·2
Saturated fatty acids		
Palmitic acid	$1·7 \times 10^7$	37·8
Stearic acid	$1·9 \times 10^7$	12·9
Sterols		
Cholesterol	$6·9 \times 10^6$	88·1
Ergosterol	$2·5 \times 10^7$	93·0

* Potassium acetate was added directly to the medium to a concentration of 4·5 mgm./ml.; other fatty acids and the sterols were added to the medium from ethanolic solutions to concentrations of 50 μgm./ml. The ethanol content of each experimental flask, including the lipid-free control, was adjusted to a concentration of 0·2 per cent (v/v) prior to autoclaving.

mutation ; the fully saturated stearic and palmitic acids are considerably less effective in this regard while the di-unsaturated linoleic acid and the sterols, ergosterol and cholesterol, are without effect.

Evidently yeast cells require a supply of certain fatty acids in order to ensure the genetic stability of their aerobic respiratory apparatus. Their need for oleate is particularly critical. Under conditions of pantothenate deficiency, cells are incapable of providing these materials for themselves when approaching the stationary phase of growth in aerobic culture. The fact that exogenous acetate is as effective as oleic acid in satisfying this requirement establishes that the pantothenate-starved cells possess sufficient quantities of coenzyme *A* to permit an adequate rate of fatty acid production from acetate and indicates that their lipid need results from their limited ability to generate acetate during growth on glucose. It is known that yeast cells grown aerobically incorporate acetate into lipids at equivalent rates during the logarithmic and stationary phases of growth ; their ability to oxidize acetate, however, does not develop appreciably until the termination of the logarithmic phase[12]. Since the oxidation of acetate by yeast is an aerobic process, it can be concluded that pantothenate-starved cells conduct no significant acetate oxidation either during logarithmic aerobic growth or at any state of anaerobic growth. The fact that they also do not mutate under these conditions indicates that their production of acetate is at least sufficient for the biosynthesis of the fatty acids which stabilize respiration. Accordingly, the extensive mutation which pantothenate-starved cells undergo at the inception of the stationary phase of aerobic growth can be attributed to their oxidative depletion of that limited supply of endogenous acetate which is essential for biosynthetic purposes. Thus acetate metabolism does appear to be of basic importance in the genetic maintenance of cellular respiratory competence.

The respiratory activity of the normal mitochondrion depends uniquely on the structural orientation of its constituent enzymes[12]. Lipids and ribonucleic acid along with the enzymic proteins themselves contribute to the preservation of this organization. While it may be assumed that the biosyntheses of mitochondrial enzymes, like those of other enzymes, are genically directed, the fact that mitochondria do not arise *de novo* shows that their fabrication is contingent on the structural organization of pre-existent mitochondria. Thus treatments which upset normal mitochondrial organization might be expected to give rise to lines of mutant mitochondria exhibiting depressed respiratory activities. The heritable loss of respiratory competence induced in cells by pantothenate starvation can most simply be ascribed, at present, to such a disorganization resulting from a cellular deficiency for particular fatty acids.

This work was aided by a contract between the Office of Naval Research, Department of the Navy, and the University of Wichita, *NR* 103 459, and a grant from the Kansas Division of the American Cancer Society.

[1] Hirsch, H. H., *Biochim. Biophys. Acta*, **9**, 674 (1952).
[2] Ephrussi, B., and Hottinguer, H., *Cold Spring Harbor Symp. Quant. Biol.*, **16**, 75 (1951).
[3] Rant, C. J., *J. Cell. Comp. Physiol.*, **44**, 463 (1954).
[4] Yeas, M., *Exp. Cell Res.*, **10**, 746 (1956).
[5] Lindegren, C. C., *Nature*, **182**, 446 (1958).
[6] Sarachek, A., and Fowler, G. L., *Can. J. Microbiol.*, **5**, 583 (1959).
[7] Klein, H. P., and Lipman, F., *J. Biol. Chem.*, **203**, 95 (1953).
[8] Novelli, G. D., and Lipman, F., *J. Biol. Chem.*, **182**, 213 (1950).
[9] Sarachek, A., *Cytologia*, **23**, 143 (1958).
[10] Sarachek, A., *Biochim. Biophys. Acta*, **33**, 227 (1959).
[11] Klein, H. P., *Fed. Proc.*, **10**, 209 (1951).
[12] Eaton, N. R., and Klein, H. P., *J. Bacteriol.*, **68**, 110 (1954).
[13] Green, D. E., *Symp. Soc. Exp. Biol.*, No. 10, 30 (Academic Press, New York, 1957).

RADIOSENSITIZATION OF *E. COLI* BY PURINE AND PYRIMIDINE ANALOGUES INCORPORATED IN DEOXYRIBONUCLEIC ACID

By Prof. HENRY S. KAPLAN, Dr. KENDRIC C. SMITH and PATRICIA TOMLIN

Department of Radiology, Stanford University School of Medicine, Palo Alto, California

THE radiosensitivity of a given species and strain of bacteria is characteristic of that species and strain, but is subject to modification by a variety of physiological and environmental factors[1]. Among the factors which modify radiation sensitivity are oxygen[2], nitric oxide[3], and the sulphydryl-amines, such as cysteine[4], cysteamine[5] and AET[6].

A number of considerations have led investigators to postulate that the lethal effects of radiation might be mediated by damage induced in the molecular structure of the nucleic acids, in particular deoxyribonucleic acid (DNA). The discovery in recent years that certain purine and pyrimidine analogues are incorporated into bacterial DNA[7–13] makes it of interest to study the effect of the resulting alteration of molecular structure of DNA on radiosensitivity.

The work described here was initiated about a year ago[13], and is focused primarily on the X-ray sensitivity of various strains of *E. coli*, though some experiments with ultra-violet have also been performed.

Greer[14] has recently reported a striking increase of ultra-violet sensitivity in *E. coli*, strain 15*T*⁻, a thymine-deficient mutant, after incorporation of the thymine analogue, 5-bromouracil (BU). Djordjevic and Szybalski[15] have reported a similar response to ultra-violet in mammalian cells cultivated *in vitro* in the presence of 5-bromouracil deoxyriboside (BUDR), as well as the corresponding iodinated compound (IUDR). These authors also reported limited experiments with X-rays, indicating increased lethality in mammalian cells the DNA of which was labelled with these halogenated deoxyribosides.

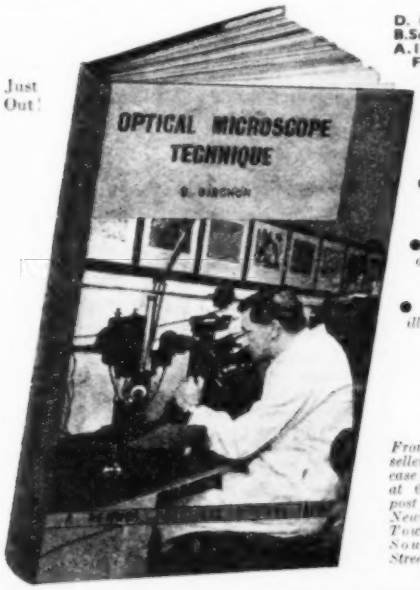
We have used the wild-type *E. coli* strains *B* (*W*3292, radiosensitive) and *B/r* (radioresistant[16]); a thymine-deficient mutant of strain *B* (*W*4516); and a purine- and thiamin-deficient mutant of strain *K*12 (*W*3687), all obtained through the kindness of Dr.

A practical guide to the basic principles of optical microscopy and also to the many specialised forms it takes today . . .

OPTICAL MICROSCOPE TECHNIQUE

D. Birchon, B.Sc., A.I.M., A.I.Mar.E., F.R.M.S.

Just Out!



- 284 *pages*
- 119 *diagrams*
- 41 *illustrations*

60s. net

From all booksellers, or, in case of difficulty, at 61s. 6d. by post from George Newnes Limited, Tower House, Southampton Street, London, W.C.2.

A NEWNES PRACTICAL SCIENCE BOOK

Books ON PURE AND APPLIED SCIENCE

LARGE STOCK ALWAYS AVAILABLE

Many of the books reviewed or mentioned in this journal are available from stock. Foreign books not in stock obtained to order with the least possible delay.

Catalogues on application. Please state interests

Scientific Lending Library

New books and latest editions available promptly

ANNUAL SUBSCRIPTION, FROM £2 - 5 - 0

Prospectus free on request

Second-hand Books

Large stock of recent editions

H. K. LEWIS & Co. Ltd.

LONDON: 136 GOWER STREET, W.C.1

Business hours—9 a.m. to 5.30 p.m., Saturday to 1 p.m.

Telephone: Euston 4282 (9 lines)

SOME PHILIPS SUCCESSES

Magnetic Sound Recording

D. A. SNEL provides a study of basic principles which apply to all makes of instruments, and includes the latest stereophonic developments.

230 pp. **26s. 6d.**

Thyratrons

C. M. SWENNE'S account of the construction, operation and characteristics of these fast switching devices, much used in relay and timing circuits, convertors, etc.

106 pp. **13s. 6d.**

Magnetrons

K. HINKEL'S short well-illustrated introduction to the applications, physical background and properties of a tube increasingly often used as a source of high-frequency energy.

102 pp. **23s. 6d.**

Tube and Semiconductor Selection Guide, 1960-61

T. J. KROES provides up to date information on the characteristics and reference numbers of Philips tubes; this edition includes base-connections.

160 pp. **13s. 6d.**

Medical X-Ray Technique

Prof. G. J. Van der PLAATS' superb reference work provides a full survey of the applied physics of the subject and reviews modern methods, including television techniques.

496 pp. **60s.**

Philips Research Reports

An authoritative journal on fundamental research, particularly solid state physics and the physico-chemical borderlands; this year, four large supplements are available free of charge to subscribers.

8s. 6d. *each.* **44s.** *subscription (6 issues)*

CLEAVER-HUME PRESS, LTD.

London: 31 Wright's Lane, Kensington, W.8

NEW!

Journal for Experimental Zoology

EDITORS:

Paul Cohrs, Hannover
Horst Heinecke, Jena
Arnold Spiegel, Hannover-Linden

The following persons belong to the advisory council at present:

A. Graffi, Berlin-Buch
R. Gönnert, Elberfeld
H. Knöll, Jena
W. Lane-Petter, Carshalton
E. Pogosianz, Moscow
H. Rährer, Isle of Riems
G. Rubenstroth-Bauer, Munich
W. Schäfer, Tübingen

In all branches of medical and biological research, there is a steady increase in the use of animals for the purpose of experimentation. The demand for quality in regard to heredity and health is more stringent than ever before. Different species of animals are being used for experimentation. This necessitates treatment of a range of problems ; for this purpose the publication of a special journal is required. In the 'Journal for Experimental Zoology,' the first of its kind on an international scale, there will appear :

Original work on anatomy, physiology (standard values), classification, ecology, history, etc., of the kinds of animals for experimentation, the care needed for them (rooms, cages, feeding, etc.), animal breeding (methods, families, genetics), illnesses of the animals (etiology, pathological anatomy, histology and physiology) and methods of preventing illness, parasites and their control, the methodology of experimentation on animals. Also there will be *survey reviews, discussions on books* and *items of news.*

Mode of publication and condition of purchase : Six copies published in an unrestricted sequence form one volume. Size of one copy is 32 printed pages. Format, 17 × 24 cm. The first copy will be edited during the second half of 1961. Price per book 4.50 D.M. approximately.

SEMPER BONUS ARTIBUS

VEB Gustav Fischer Verlag Jena
GERMAN DEMOCRATIC REPUBLIC

Schwarz Memorial Volume

ELECTRONICS FOR SPECTROSCOPISTS

By members of the Photoelectric Spectrometry Group and of the Electronics Department of Southampton University

★

Edited by C. G. CANNON, B.SC., F.INST.P., with a preface by H. W. THOMPSON, F.R.S.

Price 60s. net

HILGER & WATTS LIMITED
98 St. Pancras Way London NW1

THE MUSEUM BOOK STORE, LTD.
25 Devonshire St., London, W.1
(Welbeck 1340)
Buy and sell Scientific Journals and Periodicals and Learned Society Publications in all languages. Librarians, and others, should send us their list of "wants", or duplicates for sale. *Binding undertaken.*

Scientific Circulations Ltd.
We have extensive stocks of Technical Journals, Periodicals and Textbooks. Special terms for Technical and Commercial Libraries. All Scientific and Technical publications purchased.
111, Eastbourne Mews, London, W.2
Telephone: AMBassador 6934

GLASSWORKERS'
STRAIN-VIEWING POLARISCOPE

Full wave retardation analyser for 5800 A gives most sensitive colour indication of strain. Field and sight aperture 1½" dia. Dimensions 6½" × 5½" × 5". Price : **£11 16s. 6d.**

As above but without colour analyser showing strains against black field. Price : **£5 5s. 0d.**

Immediate Delivery.

H. S. B. MEAKIN, LTD., 35, Victoria Street, S.W.1
SUPPLIERS OF POLAROID PLASTIC and GLASS **Tel. : Abbey 6713**

MACMILLAN BOOKS

The Economic Consequences of the Size of Nations

Edited by E. A. G. ROBINSON

This was the theme of the International Economic Association's annual conference, which was held at Lisbon in 1957. Its purpose was to consider how far an increase of the size of a nation and of a national market might permit the achievement of economies otherwise unattainable. 'An immensely rich mine of ideas and facts.'—*The Economist.*

50s

Food, Land and Manpower in Western Europe

P. LAMARTINE YATES

A study of the contribution that the farm economy of Western Europe could make to general economic expansion is the central theme of this new study of the region's food supply and agricultural problems. This is the first of a series of four monographs being prepared on European problems. *35s*

Structural Concrete

KURT BILLIG

Following Professor Billig's previous books, *Prestressed Concrete* and *Precast Concrete*, this present work aims to provide a *Minor Encyclopaedia on Structural Concrete* within a single volume. The layout of the book follows the scheme established by its predecessors, with materials, design, and construction dealt with in that order.

164 figures, 73 photographs, 113 tables. 84s

Selected Lectures in Modern Physics

Edited by H. MESSEL

Teachers and others who require a refresher course in the form of brief accounts of selected topics in physics will find this book of great value, as it covers recent developments in many fields of modern physics. The lectures are not formal accounts of their subjects, but general discussions of such current topics as nuclear energy, physics in rain-making, radio astronomy, and cosmic rays. *Profusely illustrated. 30s*

ST MARTIN'S STREET LONDON WC2

Interscience Publishers

NEW YORK LONDON

INTERSCIENCE MONOGRAPHS AND TEXTS IN PHYSICS AND ASTRONOMY

Volume V

TECHNIQUES OF HIGH ENERGY PHYSICS

edited by **DAVID M. RITSON,** *Laboratory for Nuclear Science, Massachusetts Institute of Technology, Cambridge, Mass*

Since the end of World War II the style of instrumentation in high energy physics has changed radically. Unhappily, the 'fundamental' discovery of this era has been that a group employing modern engineering and organizational techniques can ask experimental questions that would have seemed inconceivable twenty years ago. The most dramatic example of this is provided by the large hydrogen bubble chamber, the utilization of heavy electrical engineering, large scale cryogenics, and advanced computer data processing. It is hoped that this book will help either to put the fields of experimentation in perspective for the professional or to communicate ideas and techniques to the beginning physicist.

552 *pages* 182 *figures* 52 *tables* **126/-**

CONTENTS :

1. General Properties of Particles and Radiation
2. Diffusion Cloud Chambers
3. Bubble Chambers
4. Nuclear Emulsions
5. Digital Computers
6. Ionization Counters
7. Scintillation and Cerenkov Counters
8. Use of Transistors in High Energy Physics Research
9. Beam Optics
10. Target Preparation
11. Beam Monitoring Methods
    Part 1—Monitoring High-Energy Proton Beams
    Part 2—Monitoring High-Energy Electron and X-ray Beams

Appendices—Index

Volume VI

PHYSICS OF THE SOLAR CHROMOSPHERE

by **RICHARD N. THOMAS,** *Boulder Laboratories, National Bureau of Standards, Boulder, Colorado,*
and **R. GRANT ATHAY,** *High Altitude Observatory, University of Colorado, Boulder, Colorado.*

This book has a dual role: that of a description of the present issues relating to the solar chromosphere, and that of a case history, in effect, of every important system in the field of gas dynamics. It will be of primary interest to astronomers as a reference and class text, and also to workers in the field of aerodynamics, magnetodynamics, solar-terrestrial relationships, and rocket and satellite instrumentation. It is actually a blend of two things: (1) an exposition of, and status report on, the development of a new methodology for the discussion and analysis of a gaseous atmosphere whose prototype is the stellar atmosphere; and (2) a summary of the application of this methodology to a particular atmosphere—the solar chromosphere—on the basis of an extensive new set of observations which had been planned and obtained as a result of the original efforts on the development of this new methodology.

432 *pages* 67 *figures* 61 *tables* **117/-**

CONTENTS :

1. The Problem of the Solar Chromosphere and Its Bearing on the General Problem of Stellar Atmospheric Structure
2. Chromospheric Data
3. Variations in Chromospheric Structure and Mass Motions
4. The Spectroscopic State of a Gas in a Statistically Steady State
5. Thermal Stability of a Gas with a Non-Radiative Energy Input and Radiative Efflux
6. The Analysis of Emission in the Optical Continuum to Obtain $n_e(h)$ and $T_e(h)$ Under the Assumption of a Spherically Symmetric Lower Chromosphere
7. Extension of the Model to Include Helium Emission
8. An Extension of the Model to Include Radio Noise Data
9. Data in Whose Analysis the Effects of Both Self-Absorption and of Departures from a State of Local Thermodynamic Equilibrium Must be Included
10. Summary Comments on the Chromospheric Model

Appendices — Bibliography — Index

To be published very shortly:

AN ATLAS OF THE MOON'S FAR SIDE: The Lunik III Reconnaissance

Compiled and edited for the U.S.S.R. Academy of Sciences by **N. N. BARABASHOV,** *Kharkov University Observatory,*
A. A. MIKHAILOV, *Pulkovo Observatory,*
Yu. N. LIPSKY, *Sternberg Astronomical Institute, Moscow University,*
and translated from the Russian by **RICHARD B. RODMAN,** *Harvard Observatory.*

First published by the U.S.S.R. Academy of Sciences as the *Atlas of the Opposite Side of the Moon* this complete English edition duplicates the Russian original in content and format. It includes exact replicas of all 20 plates containing 30 pictures of hitherto invisible features of the Moon. These pictures represent those obtained by means of electronic filtration processes from the best photographs taken by *Lunik III*. Also included are (a) the definitive map of the Moon's far side, sectionalized on 4 pages of the book, and also as a separate 17 × 24 in. insert; (b) a catalogue of 498 lunar formations identified; and (c) a full account of the working methods of analysis of the photographs.

CONTENTS :

Introduction

1. The Photographs and Their Transmission
2. Interpretive Techniques
3. The Photometric Cross Sections
4. Reduction of the Material
5. Catalogue

References

Published jointly with SKY PUBLISHING CORPORATION, Harvard.
Approx. 200 *pages,* 20 *plates of* 30 *Photographs,*
50/-

88-90 Chancery Lane, London, W.C.2

DISPERSION RELATIONS

EDITED BY G. R. SCREATON

Dispersion Relations was chosen as the subject for the Scottish Universities Summer School, held at Edinburgh in 1960 under the Directorship of Professor N. Kemmer, F.R.S. During a period of three weeks courses were given at a very advanced level, and the lectures delivered by some of the world's leading mathematical physicists and here presented in permanent form give an invaluable picture of the current state of the subject.

350 pages line diagrams **55s net**

Prospectus listing contents available

THE EARTH TODAY

EDITED BY A. H. COOK AND T. F. GASKELL

This special volume of the Geophysical Journal is being published in honour of the seventieth birthday of Sir Harold Jeffreys. It comprises papers by many of Sir Harold's distinguished colleagues and pupils, representing the most advanced work in a number of fields in which Sir Harold has long been interested. Among the subjects covered are the Earth's Gravitational Field, Seismology, Free Oscillations, Thermal State, and Geodesy.

260 pages half-tone plates **80s net**

Prospectus listing contents available

O & B **OLIVER & BOYD**

Tweeddale Court, 14 High Street,
Edinburgh 1.

Back Numbers of Periodicals for Sale

AMERICAN CHEMICAL SOCIETY JOURNAL
Vols. 1–81 Washington 1879–1959. With G.I. 1–20 and Proceedings 1/2. 1876–78. Partly bound. **£440.**

ANGEWANDTE CHEMIE
Vols. 14–72. Berlin 1901–1960. Lacks vols. 34, 37, 58. **£270.**

CHEMICAL ENGINEERING SCIENCE
Vols. 1–12. Oxford/New York 1951–1960. **£96.**

CHEMICAL SOCIETY LONDON JOURNAL
1902–1959. Lacks years 1914, 1921, 1932, and 1 index. **£380.**

CHEMIE—INGENIEUR—TECHNIK
Vols. 1–31. Berlin 1928–1959. Partly bound. **£85.**

CHEMISCHES ZENTRALBLATT
Vols. 68–131, with Annual Indices, Gen. Ind. 1–6, all Supplements and Special vols. as far as publ. to date. (Lacks vol. 111, pp. 2497–4690 and Subject-Formula Index in vol. 110, pp. 3277–3306 (contents) in vol. 112, Supplement No. 4 to vol. 120, Subject Index L–Z in vol. 123 and Aut/Pat. Index Pt. 1 in vol. 128). Berlin, 1897–1960. 45 vols. are bound. **£1,490.**

INSTITUTION OF THE RUBBER INDUSTRY LONDON TRANSACTIONS
Vols. 1–32/Nos. 1–5. London (1925–1956). With G.I. 1–20 and Yearbook for 1923–24. Lacks 21 tpi's. **£170.**

JOURNAL OF INORGANIC AND NUCLEAR CHEMISTRY
Vols. 1–15. Oxford/New York 1955–1960. Lacks vol. 8. **£112.**

We hold in Oxford and New York a comprehensive stock of British, Continental and American Periodicals and frequently issue catalogues. Please send your lists of requirements.

I. R. MAXWELL and Co. Ltd.
Headington Hill Hall, Oxford
Tel. 64881. Cables: LEXICOM. Telex 83177.
Offices also at:
103, Fifth Avenue, New York 3, Tel. Chelsea 2–2100.
Kaiserstrasse 75, Frankfurt am Main. Tel. 33.74.61.
24 rue des Ecoles, Paris Ve. Tel. ODEon 30–00.

INTERNAL MAGNET SYSTEMS

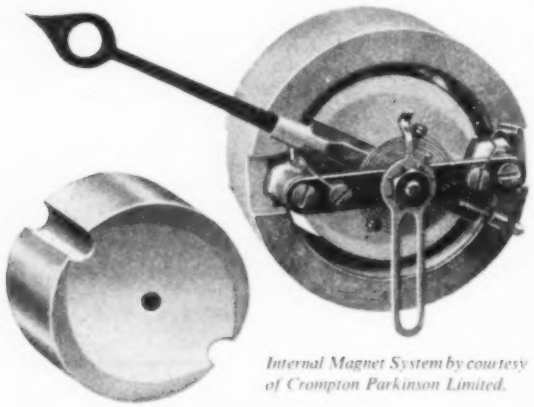
The internal magnet system was developed originally about 30 years ago but it is only in recent years that this method has been used on a large scale. The basic principle is simple; instead of a coil working around an iron concentrator in the pole tunnel of a large magnet assembly, the concentrator is replaced by a cylindrical magnet with iron pole shoes attached to give a linear distribution of flux. The coil then swings between the magnet assembly and an outer iron ring, which provides the return circuit and a shield against stray fields.

Usually, the pole shoes are either fixed by an adhesive or by solder or are dovetailed into the periphery of the magnet. All these methods however, introduce gaps of high reluctance in the circuit and difficulties can also arise in attaching the shoes accurately and firmly in position.

THE 'SINCOMAX' TECHNIQUE

Powder Metallurgy and the "Sincomax" technique, developed by Murex Limited, applied to the manufacture of this type of assembly, have now made possible magnet units of reliable and consistent performance. The problem of attaching the iron shoes has been completely overcome by the application of the "Sincomax" technique, which enables magnet material and iron powder to be pressed and subsequently furnaced as one piece to form a single composite unit of high bond strength having a definite line of demarcation between the two materials.

The pole shoes of high-density magnetic iron can be thin in section and can be designed to give a linear distribution of flux over their entire length. Provision can be made to accommodate supports or pillars without affecting the overall cost of the assembly.



Internal Magnet System by courtesy of Crompton Parkinson Limited.

ACTUAL SIZE OF MAGNET

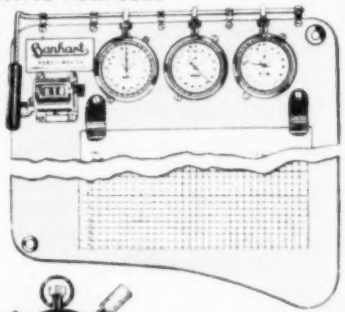
Murex Limited have many years experience in the manufacture of magnets by the Powder Metallurgy technique and qualified technical staff are available to advise on magnet design and performance.

MUREX LTD *(Powder Metallurgy Division)*
Rainham, Essex *Rainham, Essex 3322*
Telex 28632 Telegrams: Murex, Rainham-Dagenham Telex.
London Sales Office: Central House, Upper Woburn Place, W.C.1. Tel. EUSton 8265

Hanhart STOP WATCHES

FOR INDUSTRY, EDUCATION, RESEARCH AND ALL SCIENTIFIC PURPOSES

ALL CALIBRATIONS AVAILABLE



ROBOTIMER
Type 38.10
Each operation automatically starts 'A', zeros 'B' and stops 'C'
£27 10 0.

Split Action Timer
Type 786.5 1 sec. 30 min. recorder
£11 3 6.

Electrically Actuated
4½–7 Volt—All calibrations available

- Dust and water protected.
- Shockproof; unbreakable mainspring.
- Available in any desired calibration.
- Fully guaranteed for 12 months.
- 48 hour return post repair service.
- Your specific enquiries invited.

Fully illustrated catalogue from the Sole U.K. Distributors

CHRONOTIME
(Dept. N.4) · 314, HIGH HOLBORN, LONDON, W.C.1
Telephone—CHANCERY 8655 6

BACK ISSUES OF JOURNALS IN SCIENCE & THE HUMANITIES
ALWAYS REQUIRED BY:
WM. DAWSON & SONS, LTD.,
BACK ISSUES DEPT.,
16 WEST STREET,
FARNHAM, SURREY, ENGLAND.
TEL: FARNHAM 4664 CABLES: DAWBOOKS, FARNHAM

"ESCORUBBER"
RUBBER CLOSURES FOR BLOOD TRANSFUSION
Ref. No. P2, highest quality rubber, at 30 - per gross
ESCO (RUBBER) LTD.
34/36 Somerford Grove, London, N.16

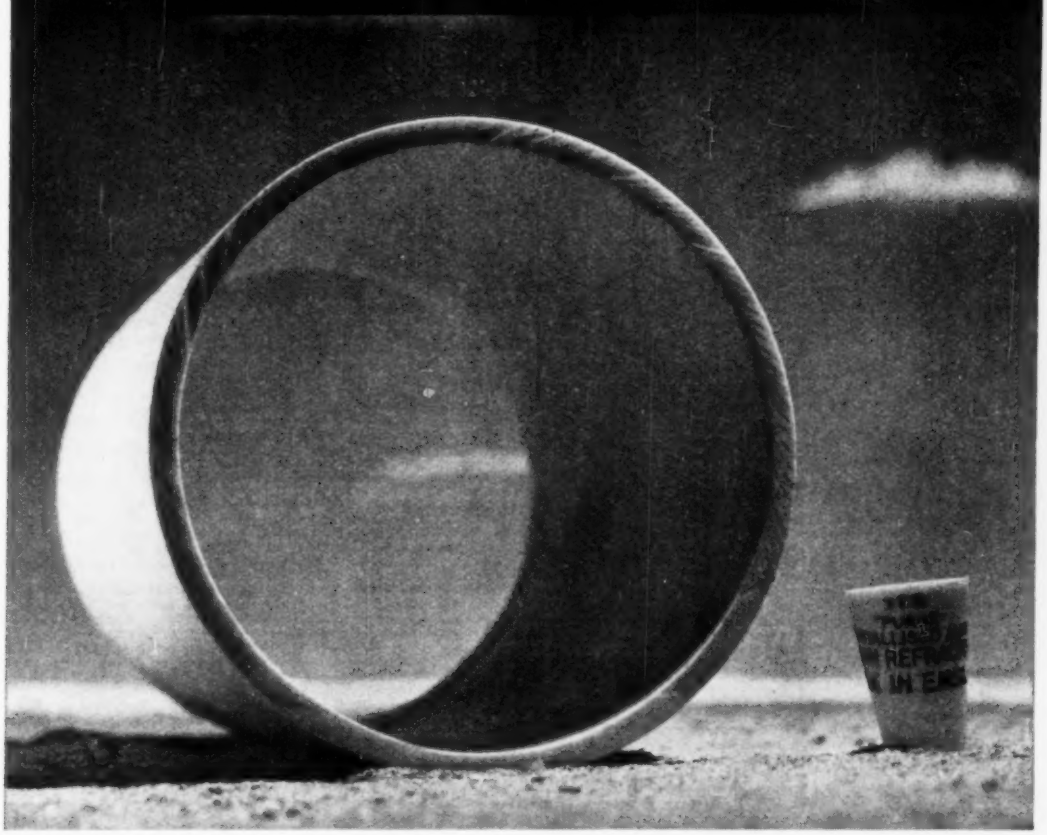
"GURR'S" *is the Registered Trade Mark of* **GEORGE T. GURR LTD.**
Since 1915 **"GURR'S"** brand of **MICROSCOPICAL STAINS** and Reagents has become world-famous.
If you want this world-famous brand specify **"GURR'S"** and refuse any other.
Ask for catalogues
GEORGE T. GURR LTD.
136-138 NEW KINGS ROAD, LONDON, S.W.6

All communications regarding advertising in NATURE should be addressed to:
T. G. SCOTT & SON LTD.,
1 Clement's Inn, London, W.C.2

PUROX*

* Registered trade-name

RECRYSTALLISED ALUMINA 99.7% Al_2O_3
STABILISED ZIRCONIA 97% ZrO_2
PURE MAGNESIA 98% MgO
IMPERVIOUS THORIA 99.9% ThO_2
THORIA 99.9% ThO_2



At Neston we make high-temperature, high-purity refractories, in such materials as Thoria and Magnesia, which cannot be bettered by refractories made anywhere else in the world. Collectively these with other very pure Recrystallised Alumina and Zirconia refractories are known as Purox. Newly developed techniques allow us to make these refractories in sizes, and with an intricacy of form, that would have been impossible even a year or two ago. So when a job demands a refractory that seems unobtainable you may find what you need at . . .

MORGAN Refractories Ltd

MORGAN REFRACTORIES LIMITED · NESTON · WIRRAL · CHESHIRE · TELEPHONE: NESTON 1406
NE155/A

RECENT SCIENTIFIC and TECHNICAL BOOKS

Volumes marked with an asterisk (*) have been received at "Nature" Office

Mathematics

ARROW, Kenneth J., KARLIN, Samuel, and SUPPES, Patrick (edited by). Mathematical Methods in the Social Sciences, 1959 : Proceedings of the First Stanford Symposium. (Stanford Mathematical Studies in the Social Science, IV.) 9½ in. × 6½ in. (24 cm. × 16 cm.). Pp. viii + 365. (Stanford, Calif. : Stanford University Press ; London : Oxford University Press, 1960.) 60s. net.*

FRAENKEL, Abraham A. Abstract Set Theory. Second, completely revised edition. (Studies in Logic and the Foundations of Mathematics.) 9 in. × 6½ in. (23 cm. × 16 cm.). Pp. viii + 295. (Amsterdam : North-Holland Publishing Company, 1961.) 60s.*

MACMAHON, Percy A. Combinatory Analysis. (2 vols. in 1.) 8½ in. × 5½ in. (21 cm. × 14 cm.). Pp. xxxviii + 642. (New York : Chelsea Publishing Company, 1960.) 7·50 dollars.*

NIVEN, Ivan, and ZUCKERMAN, Herbert S. An Introduction to the Theory of Numbers. 9 in. × 6 in. (23 cm. × 15·5 cm.). Pp. viii + 250. (New York and London : John Wiley and Sons, Inc., 1960.) 50s. ; 6·25 dollars.*

ROTENBERG, Manuel, BIVINS, R., METROPOLIS, N., and WOOTEN, Jr., John K. The 3-j and 6-j Symbols. 11½ in. × 8½ in. (28·5 cm. × 22 cm.). Pp. viii + 498. (London : Crosby Lockwood and Son, Ltd., 1959.) 120s. net.*

SALMON, George. A Treatise on the Higher Plane Curves. Third edition. 8½ in. × 5½ in. (21 cm. × 13 cm.). Pp. xix + 395. (New York : Chelsea Publishing Company, 1960.) 4·95 dollars.*

WEYL, H., LANDAU, E., und RIEMANN, B. Das Kontinuum und Andere Monographien. 8½ in. × 5½ in. (21 cm. × 13 cm.). Pp. iv + 370. (New York : Chelsea Publishing Company.) 6 dollars.*

YOSIDA, Kôsaku. Lectures on Differential and Integral Equations. (Pure and Applied Mathematics : a Series of Texts and Monographs, Vol. 10.) 9 in. × 6 in. (23 cm. × 15·5 cm.). Pp. ix + 220. (New York : Interscience Publishers, Inc. ; London : Interscience Publishers, Ltd., 1960.) 53s.*

Physics

AESCHLIMANN, F. Recherches sur la Notion de Système Physique. (Les Grands Problèmes des Sciences, Vol. 11.) 9½ in. × 6 in. (24 cm. × 15·5 cm.). Pp. ix + 250. (Paris : Gauthier-Villars, 1960.) 40 N.F. ; 8.50 dollars.*

BAHN, Gilbert S., and ZUKOSKI, Edward E. (edited by). Kinetics, Equilibria and Performance of High Temperature Systems : Proceedings of the First Conference, Western States Section, The Combustion Institute, Los Angeles, California, 3–5, November 1959. 10½ in. × 7 in. (26 cm. × 18 cm.). Pp. x + 255. (London : Butterworth and Co. (Publishers), Ltd., 1960.) 80s.*

BLANC, Daniel, et AMBROSINO, Georges. Eléments de Physique Nucléaire. 9½ in. × 6½ in. (24 cm. × 16 cm.). Pp. 238. (Paris : Masson et Cie., 1960.) 30 N.F.*

BRACEY, R. J. The Technique of Optical Instrument Design. (Applied Physics Guides.) 8½ in. × 5½ in. (22 cm. × 14 cm.). Pp. 316. (London : English Universities Press, 1960.) 35s. net.*

BROWN, R. C. Electricity and Magnetism. (A Textbook of Physics, Vol. 5.) 8½ in. × 5½ in. (22 cm. × 15 cm.). Pp. viii + 1019–1424. (London : Longmans, Green and Co., Ltd., 1960.) 20s.*

GOL'DMAN, I. I., KRIVCHENKOV, V. D., KOGAN, V. I., and GALITSKII, V. M. Problems in Quantum Mechanics. Translated, edited and arranged by D. ter Haar. 9½ in. × 6½ in. (23·5 cm. × 16 cm.). Pp. iii + 394. (London : Infosearch Limited, 1960. Distributed by Cleaver-Hume Press, Ltd.). 42s.*

MACKINNON, M. A Textbook on Light at an Introductory Level. 8½ in. × 5½ in. (22 cm. × 15 cm.). Pp. xi + 344 + 4 plates. (London : Longmans, Green and Co., Ltd., 1961.) 17s. 6d.*

MacMILLAN, William Duncan. Dynamics of Rigid Bodies. Enlarged edition. 8 in. × 5½ in. (20 cm. × 13 cm.). Pp. xiii + 478. (New York : Dover Publications, Inc. ; London : Constable and Co., Ltd., 1960.) 2 dollars.*

MASSEY, Sir Harrie. The New Age in Physics. 8½ in. × 5½ in. (22 cm. × 15 cm.). Pp. 342 + 12 plates (London : Elek Books Ltd. 1960.) 42s. net.*

PALACIOS, Julio. Analyse Dimensionnelle. Traduit de l'Espagnol par Jean Prévot. (Les Grands Problèmes des Sciences, Vol. 11.) 9½ in. × 6 in. (24 cm. × 15·5 cm.). Pp. xv + 206. (Paris : Gauthier-Villars, 1960.) 40 N.F. ; 8.50 dollars.*

PEPINSKY, Ray, ROBERTSON, J. M., and SPEAKMAN, J. C. (edited by). Computing Methods and the Phase Problem in X-ray Crystal Analysis : Report of a Conference held at Glasgow, August, 1960. (International Tracts in Computer Science and Technology and their Application, Vol. 4.) 9 in. × 6 in. (23 cm. × 15·5 cm.). Pp. viii + 326. (London and New York : Pergamon Press, 1961.) 63s. net.*

ROUTH, Edward John. The Elementary Part of a Treatise on the Dynamics of a System of Rigid Bodies. Seventh edition, revised and enlarged. 8 in. × 5½ in. (20 cm. × 13 cm.). Pp. xvi + 443. (New York : Dover Publications, Inc. ; London : Constable and Co., Ltd., 1960.) 2.35 dollars.*

Engineering

BARDELL, P. R. Magnetic Materials in the Electrical Industry. Second edition (revised). 8½ in. × 5½ in. (22 cm. × 15 cm.). Pp. 320. (London : Macdonald and Co. (Publishers), Ltd., 1960.) 32s. 6d. net.*

DUCARME, J., GERSTEIN, Melvin, and LEFEBVRE, A. H. (edited by). Progress in Combustion Science and Technology, Vol. I. (International Series of Monographs in Aeronautics and Astronautics. Division III : Propulsion Systems including Fuels, Vol. 2). 9 in. × 6 in. (23 cm. × 15·5 cm.). Pp. vii + 226. (London and New York : Pergamon Press, 1960.) 70s. net.*

EVANS, W. H. Experiments in Electronics. (Prentice-Hall Electrical Engineering Series.) 9½ in. × 6½ in. (23·5 cm. × 16 cm.). Pp. ix + 374. (Englewood Cliffs, N.J., and London : Prentice-Hall, Inc., 1959.) 50s.*

GATLAND, Kenneth W. (edited by). Spaceflight Technology : Proceedings of the First Commonwealth Spaceflight Symposium organized by the British Interplanetary Society, 1959. 9 in. × 6 in. (23 cm. × 15·5 cm.). Pp. xv + 365. (London : Academic Press, Inc. (London), Ltd. ; New York : Academic Press, Inc., 1960.) 75s.*

HAMMOND, Rolt. Foundations and Soil Properties : a Practical Guide to the Methods of Improving the Physical Properties of Ground to Increase its Strength. 8½ in. × 5½ in. (21·5 cm. × 14 cm.). Pp. vii + 181. (London : Macdonald and Co. (Publishers), Ltd., 1961.) 30s. net.*

HAMMOND, Rolt. British Nuclear Power Stations. 8½ in. × 5½ in. (22 cm. × 15 cm.). Pp. vi + 182 + 18 plates. (London : Macdonald and Co. (Publishers), Ltd., 1961.) 25s. net.*

HOGARTH, C. A., and BLITZ, J. (edited by). Techniques of Non-Destructive Testing. 8½ in. × 5½ in. (22 cm. × 14 cm.). Pp. vii + 216. (London : Butterworth and Co. (Publishers), Ltd., 1960.) 40s.*

Chemistry : Chemical Industry

HAYNES, B. Qualitative Organic Analysis. 10 in. × 7½ in. (25·5 cm. × 18·5 cm.). Pp. 239. (London : Cleaver-Hume Press, Ltd., 1961.) 17s. 6d.*

HORWITZ, William (edited by). Official Methods of Analysis of the Association of Official Agricultural Chemists. Ninth edition. 10½ in. × 7 in. (26·5 cm. × 18 cm.). Pp. xx + 832. (Washington, D.C. : Association of Official Agricultural Chemists, 1960.) 18 dollars.*

JORDAN, D. O. The Chemistry of Nucleic Acids. 8½ in. × 5½ in. (22 cm. × 15 cm.). Pp. ix + 358 + 8 plates. (London : Butterworth and Co. (Publishers), Ltd., 1960.) 60s.*

KOCH, R. C. Activation Analysis Handbook. 10½ in. × 8½ in. (26·5 cm. × 21 cm.). Pp. x + 219. (New York : Academic Press, Inc. ; London : Academic Press, Inc. (London), Ltd., 1960.) 8 dollars.*

LIEBHAFSKY, H. A., PFEIFFER, H. G., WINSLOW, E. H., and ZEMANY, P. D. X-ray Absorption and Emission in Analytical Chemistry : Spectrochemical Analysis with X-rays. 9½ in. × 6 in. (23·5 cm. × 15·5 cm.). Pp. x + 357. (New York and London : John Wiley and Sons, Inc., 1960.) 13.50 dollars ; 108s.*

McINTOSH, A. B., and HEAL, T. J. (edited by). Perchlorates : Their Properties, Manufacture and Uses. (American Chemical Society Monograph Series, No. 146.) 9 in. × 6 in. (23 cm. × 15·5 cm.). Pp. xii + 257. (New York : Reinhold Publishing Corporation ; London : Chapman and Hall, Ltd., 1960.) 70s. net.*

MARKLEY, K. S. (edited by). Fatty Acids : Their Chemistry, Properties, Production, and Uses, Part 1. Second, completely revised and augmented edition. (Fats and Oils : a Series of Monographs on the Chemistry and Technology of Fats, Oils and Related Products.) 9 in. × 6 in. (23 cm. × 15·5 cm.). Pp. ix + 714. (New York : Interscience Publishers, Inc. ; London : Interscience Publishers, Ltd., 1960.) 169s.*

REILLY, Charles N. (edited by). Advances in Analytical Chemistry and Instrumentation, Vol. 1. 9 in. × 6 in. (23 cm. × 15·5 cm.). Pp. vii + 445. (New York : Interscience Publishers, Inc. ; London : Interscience Publishers, Ltd., 1960.) 90s.*

SALINE WATER CONVERSION : Symposium on Saline Water Conversion, presented before the Division of Water and Waste Chemistry, at the 137th National Meeting of the American Chemical Society. (Advances in Chemistry Series, No. 27.) 9¼ in. × 6 in. (23·5 cm. × 15·5 cm.). Pp. vi + 246. (Washington, D.C. : American Chemical Society, 1960.) 5.85 dollars.*

SAUCHELLI, Vincent (edited by). Chemistry and Technology of Fertilizers. (American Chemical Society Monograph Series, No. 148.) 9 in. × 6 in. (23 cm. × 15·5 cm.). Pp. x + 692. (New York : Reinhold Publishing Corporation ; London : Chapman and Hall, Ltd., 1960.) 144s. net.*

SEGAL, Jacob, DORNBERGER-SCHIFF, Kate, and KALAIDJIEV, Angel. Globular Protein Molecules : Their Structure and Dynamic Properties. 9½ in. × 6½ in. (23·5 cm. × 17 cm.). Pp. xii + 150. (Berlin : Deutscher Verlag der Wissenschaften, 1960.) 19·80 D.M.*

TIMMERMANS, Jean. The Physico-Chemical Constants of Binary Systems in Concentrated Solutions. Vol. 4 : Systems with Inorganic + Organic or Inorganic Compounds (Excepting Metallic Derivatives). 9½ in. × 7½ in. (24 cm. × 18·5 cm.). Pp. xi + 1332. (New York : Interscience Publishers, Inc. ; London : Interscience Publishers, Ltd., 1960.) 293s.*

VEIBEL, Stig. The Identification of Organic Compounds : a Manual of Qualitative and Quantitative Methods. Fifth edition (second English edition). 8½ in. × 5½ in. (21·5 cm. × 15 cm.). Pp. xvi + 426. (Copenhagen : G. E. C. Gad, 1961.) n.p.*

WHELAND, G. W. Advanced Organic Chemistry. Third edition. 9½ in. × 6 in. (23·5 cm. × 15·5 cm.). Pp. xi + 871. (New York and London : John Wiley and Sons, Inc., 1960.). 17.50 dollars ; 140s.*

Technology

BOLTON, Ronald Lomax, and KLEIN, Louis. Sewage Treatment : Basic Principles and Trends. 8½ in. × 5½ in. (22 cm. × 15 cm.). Pp. vii + 161. (London : Butterworth and Co. (Publishers), Ltd., 1961.) 30s.*

ELECTRON MICROSCOPY IN ANATOMY : Proceedings of a Symposium held by the Anatomical Society of Great Britain on the Ultra-Structure of Cells. 9 in. × 6 in. (23 cm. × 15·5 cm.). Pp. viii + 288. (London : Edward Arnold (Publishers), Ltd., 1961.) 50s. net.*

GROVER, Elliot B., and HAMBY, D. S. Handbook of Textile Testing and Quality Control. 9½ in. × 6½ in. (23·5 cm. × 16 cm.). Pp. vi + 614. (New York : Textile Book Publishers, Inc. ; London : Interscience Publishers, Ltd., 1960.) 132s.*

LUMB, Ralph F. (edited by). Management of Nuclear Materials. (Prepared under the auspices of the Office of Technical Information, United States Atomic Energy Commission.) 9 in. × 6 in. (23 cm. × 15·5 cm.). Pp. vii + 516. (Princeton, N.J. : D. Van Nostrand Company, Inc. ; London : D. Van Nostrand Company, Ltd., 1960.) 124s.*

NOTES ON OPERATIONS RESEARCH. Assembled by the Operations Research Center, M.I.T. 9 in. × 6 in. (23 cm. × 15·5 cm.). Pp. viii + 256. (London : Crosby Lockwood and Son, Ltd., 1959.) 30s.*

Astronomy

ARTHUR, D. W. G., and WHITAKER, E. A. (compiled by). KUIPER, Gerard P. (edited by). Orthographic Atlas of the Moon. Part I : Central Area. Supplement No. 1 to the "Photographic Lunar Atlas". Edition "A" showing the Standard Orthographic Co-ordinate Grid. (Contributions, Lunar and Planetary Laboratory, No. 1.) Pp. 3 + 31 plates. (Tucson: University of Arizona Press, 1960.) n.p.*

HOYLE, Fred. Frontiers of Astronomy. 8½ in. × 5½ in. (21·5 cm. × 14 cm.). Pp. xvi + 360 + 59 plates. (London : Mercury Books, 1961. Originally published 1955.) 12s. 6d.*

PAUL, Henry E. Outer Space Photography for the Amateur. 8½ in. × 5 in. (21 cm. × 12·5 cm.). Pp. iv + 124. (New York : Amphoto, 1960.) 2.50 dollars.*

STERNE, Theodore E. An Introduction to Celestial Mechanics. (Interscience Tracts on Physics and Astronomy.) 8½ in. × 5½ in. (21 cm. × 14 cm.). Pp. xi + 206. (New York : Interscience Publishers, Inc. ; London : Interscience Publishers, Ltd., 1960.) Cloth 34s. ; Paper 19s.*

Meteorology : Geophysics

ANDERSON, Charles E. (edited by). Cumulus Dynamics : Proceedings of the First Conference on Cumulus Convection held at Portsmouth, New Hampshire, 19–22 May 1959. 10 in. × 7½ in. (25·5 cm. × 19 cm.). Pp. ix + 211. (London and New York : Pergamon Press, 1960.) 70s. net.*

ANTARCTIC METEOROLOGY : Proceedings of the Symposium held in Melbourne, February 1959. (Commonwealth of Australia : Bureau of Meteorology.) 10 in. × 6½ in. (25·5 cm. × 16 cm.). Pp. xviii + 483. (London and New York : Pergamon Press, 1960.) 105s. net.*

HESS, Seymour L. Introduction to Theoretical Meteorology. 9½ in. × 6½ in. (24 cm. × 16 cm.). Pp. xiv + 362. (New York : Henry Holt and Company ; London : Constable and Co., Ltd., 1959.) 60s. net.*

MUNK, Walter H., and MACDONALD, Gordon, J. F. The Rotation of the Earth : a Geophysical Discussion. (Cambridge Monographs on Mechanics and Applied Mathematics.) 8½ in. × 5½ in. (21·5 cm. × 14 cm.). Pp. xix + 323. (Cambridge : At the University Press, 1960.) 70s. net.*

General Biology : Natural History
Zoology : Botany

AINSWORTH AND BISBY'S DICTIONARY OF THE FUNGI. Fifth edition by Dr. G. C. Ainsworth. 7½ in. × 5 in. (19 cm. × 12·5 cm.). Pp. viii + 547. (Kew, Surrey : Commonwealth Mycological Institute, 1961.) 30s.*

BONNET, Louis, et THOMAS, Raymond. Thécamoebiens du Sol. (Faune Terrestre et d'Eau Douce des Pyrénées-Orientales, Fascicule 5.) 9½ in. × 6½ in. (24 cm. × 16 cm.). Pp. 103. (Paris : Hermann, 1960.) n.p.*

CLARK, Paul F. Pioneer Microbiologists of America. 9½ in. × 6½ in. (24 cm. × 16 cm.). Pp. xiv + 369. (Madison : University of Wisconsin Press, 1961.) 6 dollars.*

COPLEY, A. L., and STAINSBY, G. (edited by). Flow Properties of Blood and other Biological Systems : Proceedings of an Informal Discussion convened jointly by the Faraday Society (Colloid and Biophysics Committee) and the British Society of Rheology, held at the University Laboratory of Physiology, Oxford, 23–24 September, 1959. 8½ in. × 5½ in. (22 cm. × 15 cm.). Pp. xviii + 446. (London and New York : Pergamon Press, 1960.) 75s. net.*

DE ROPP, Robert S. Man Against Aging. 8½ in. × 5½ in. (21·5 cm. × 14 cm.). Pp. v + 310. (London : Victor Gollancz, Ltd., 1961.) 21s. net.*

DILLON, Elizabeth S., and DILLON, Lawrence S. A Manual of Common Beetles of Eastern North America. 8½ in. × 5½ in. (21·5 cm. × 14 cm.). Pp. viii + 884 (85 plates). (Evanston, Ill. : Row, Peterson and Company, 1961.) 9.25 dollars.*

HASKELL, Gordon. Practical Heredity with Drosophila. 7½ in. × 4½ in. (18·5 cm. × 12 cm.). Pp. xii + 124. (Edinburgh and London : Oliver and Boyd, Ltd., 1961.) 10s. 6d.*

JACOBS, Morris B., and GERSTEIN, Maurice J. Handbook of Microbiology. 9½ in. × 6½ in. (25 cm. × 16·5 cm.). Pp. x + 322. (Princeton, N. J. : D. Van Nostrand Company, Inc. ; London : D. Van Nostrand Company, Ltd., 1960.) 64s.*

MACKWORTH-PRAED, C. W., and GRANT, C. H. B. Birds of Eastern and North Eastern Africa. Second edition. (African Handbook of Birds, Series 1, Vol. 2.) 8½ in. × 6 in. (22 cm. × 15·5 cm.). Pp. viii + 1113 + plates 54–96 + photographs 7–19. (London : Longmans, Green and Co., Ltd., 1960.) 50s. net.*

MARTIGNONI, Mauro E., and STEINHAUS, Edward A. Laboratory Exercises in Insect Microbiology and Insect Pathology. 10½ in. × 8½ in. (27 cm. × 21·5 cm.). Pp. x + 75. (Minneapolis, Minn. : Burgess Publishing Company, 1961.) 3 dollars.*

PURCHON, R. D. (edited by). Proceedings of the Centenary and Bicentenary Congress of Biology, Singapore, December 2–9, 1958. (Papers delivered in the University of Malaya in commemoration of the works of Darwin, Wallace and Linnaeus.) 10 in. × 7½ in. (25·5 cm. × 19 cm.). Pp. viii + 333. (Singapore : University of Malaya Press ; London : Oxford University Press, 1960.) 13·50 Malayan dollars : 31s. 6d. net.*

SIMPSON, George Gaylord. The Meaning of Evolution : a Study of the History of Life and of Its Significance for Man. 8 in. × 5½ in. (20 cm. × 13 cm.). Pp. xv + 364. (New Haven, Conn. : Yale University Press ; London : Oxford University Press, 1960.) 1.45 dollars ; 11s. 6d.*

STAPP, C. Bacterial Plant Pathogens. Translated by A. Schoenfeld. 9½ in. × 6½ in. (24 cm. × 16 cm.). Pp. xviii + 292. (London : Oxford University Press, 1961.) 42s. net.*

STEEDMAN, H. F. Section Cutting in Microscopy. 9 in. × 5½ in. (23 cm. × 15 cm.). Pp. vi + 172. (Oxford : Blackwell Scientific Publications ; Springfield, Ill. : Charles C. Thomas, 1960.) 21s. net.*

WEICHERT, Charles K. Representative Chordates : a Manual of Comparative Anatomy. Second edition. (McGraw-Hill Publications in the Zoological Sciences.) 9 in. × 6½ in. (23 cm. × 16 cm.). Pp. vii + 218. (New York : McGraw-Hill Book Company, Inc. ; London : McGraw-Hill Publishing Company, Ltd., 1961.) 33s.*

WERMUTH, H., und MERTENS, R. Schildkroten—Krokodile—Brueckenechsen. 9½ in. × 6½ in. (23·5 cm. × 17 cm.). Pp. xxvi + 422. (Jena : Gustav Fischer Verlag, 1961.) 62 D.M.*

WESTCOTT, Cynthia. Plant Disease Handbook. Second edition. 9½ in. × 6½ in. (23·5 cm. × 16 cm.). Pp. xii + 825. (Princeton, N.J. : D. Van Nostrand Company, Inc. ; London : D. Van Nostrand Company, Ltd., 1960.) 101s. 6d.*

Biochemistry : Physiology

ALLEN, Mary Belle (edited by). Comparative Biochemistry of Photoreactive Systems. (Symposia on Comparative Biology, Vol. I.) 9 in. × 6 in. (23 cm. × 15·5 cm.). Pp. xii + 437. (New York : Academic Press, Inc. ; London : Academic Press, Inc. (London), Ltd., 1960.) 12 dollars.*

ARMITAGE, P. Sequential Medical Trials. 8½ in. × 5½ in. (22 cm. × 15 cm.). Pp. vi + 105. (Oxford : Blackwell Scientific Publications ; Springfield, Ill. : Charles C. Thomas, 1960.) 20s. net.*

BRAZIER, Mary A. B. (edited by). The Central Nervous System and Behaviour : Transactions of the Third Conference, February 21, 22, 23, 24, 1960, Princeton, N.J. 9½ in. × 6½ in. (23·5 cm. × 16 cm.). Pp. 475. (New York : Josiah Macy, Jr. Foundation, 1960.) 7.50 dollars.*

DE, S. N. Cholera : Its Pathology and Pathogenesis. 8½ in. × 5½ in. (22 cm. × 15 cm.). Pp. xi + 141. (Edinburgh and London : Oliver and Boyd, Ltd., 1961.) 25s. net.*

HAIDRN, Ernst. Developmental Genetics and Lethal Factors. Translated by Ursula Mittwoch. 9½ in. × 6½ in. (24 cm. × 16 cm.). Pp. xviii + 355. (London : Methuen and Co., Ltd. ; New York : John Wiley and Sons, Inc., 1961.) 52s. 6d. net.*

KISS, Ferenc, and SZENTÁGOTHAI, János (edited by). Atlas of Human Anatomy. Contributor : István Munkacsi. Vol. 1 : Osteology—Syndesmology—Myology. Pp. 297. Vol. 2 : Pp. Splanchnology—Endocrine Glands—Heart. Pp. 214. Vol. 3 : Nervous System—Vascular System—Lymphatic System—Sense Organs. Pp. 289. Eighth edition. 11¼ in. × 8½ in. (29 cm. × 21 cm.). (Budapest : Publishing House of the Hungarian Academy of Sciences—Publishing House Medicina ; London : Collet's Holdings, Ltd., 1960.) 180s. the three volumes.*

LECTURES ON THE SCIENTIFIC BASIS OF MEDICINE, Vol. 8, 1958–59. (British Postgraduate Medical Federation—University of London.) 8½ in. × 5½ in. (22 cm. × 15 cm.). Pp. ix + 467 + 36 plates. (London : The Athlone Press, University of London, 1960. Distributed by Constable and Co., Ltd.) 45s. net.*

REY, Louis, et collaborateurs. Traité de Lyophilisation. 9½ in. × 7 in. (25 cm. × 18 cm.). Pp. vii + 412. (Paris : Hermann, 1960.) 90 N.F.*

VON BAHR, G., BIETTI, G. B., TEN DOESSCHATE, J., FISCHER VON BÜNAU, H., FRANCOIS, J., GOLDMANN, H., MÜLLER, H. K., NORDMANN, Jean, SCHAEFFER, A. J., and SORSBY, Arnold. Documenta Ophthalmologica : Advances on Ophthalmology, Vol. 14. 9½ in. × 6½ in. (24 cm. × 16·5 cm.). Pp. v + 413. (The Hague : Dr. W. Junk, 1960.) 72 Dutch guilders.*

WATSON, Bernard (edited by). The Delayed Effects of Whole-Body Radiation : a Symposium. (Jointly sponsored by the Operations Research Office and the Walter Reed Army Institute of Research.) 10½ in. × 8 in. (27 cm. × 20 cm.). Pp. ix + 80. (Baltimore, Md. : The Johns Hopkins Press ; London : Oxford University Press, 1960.) 36s. net.*

WIRTSCHAFTER, Zolton T. The Genesis of the Mouse Skeleton : a Laboratory Atlas. 11½ in. × 14 in. (29 cm. × 35·5 cm.). Pp. xiii + 169. (Springfield, Ill. : Charles C. Thomas ; Oxford : Blackwell Scientific Publications, 1960.) 94s.*

WOLSTENHOLME, G. E. W., and O'CONNOR, Cecilia M. (edited by). Regulation of the Inorganic Ion Content of Cells. (Ciba Foundation Study Group, No. 5.) 7½ in. × 5 in. (19 cm. × 12·5 cm.). Pp. viii + 100. (London : J. and A. Churchill, Ltd., 1960.) 12s. 6d. net.*

Philosophy : Psychology

ABRAHAMSON, David. The Psychology of Crime. 9½ in. × 6½ in. (23·5 cm. × 16 cm.). Pp. xii + 358. (New York : Columbia University Press ; London : Oxford University Press, 1960.) 48s. net.*

HONKAVAARA, Sylvia. The Psychology of Expression : Dimensions in Human Perception. (*The British Journal of Psychology*, Monograph Supplement, No. 32.) 9½ in. × 7½ in. (25 cm. × 18·5 cm.). Pp. x + 96. (Cambridge : At the University Press, 1961.) 25s. net.*

TEMPERLEY, H. N. V. A Scientist Who Believes in God. 7½ in. × 5½ in. (19·5 cm. × 14 cm.). Pp. 176. (London : Hodder and Stoughton, Ltd., 1961.) 15s. net.*

THORPE, W. H., and ZANGWILL, O. L. (edited by). Current Problems in Animal Behaviour. 8½ in. × 5½ in. (22 cm. × 15 cm.). Pp. xiv + 424 + 2 plates. (Cambridge : At the University Press, 1961.) 45s. net.*

Miscellany

BALLENTYNE, D. W. G., and WALKER, L. E. Q. A Dictionary of Named Effects and Laws in Chemistry, Physics and Mathematics. 8½ in. × 5½ in. (22 cm. × 14 cm.). Pp. v + 234. (London : Chapman and Hall, Ltd., 1961.) 30s. net.*

DAHLBERG, Arthur. Money in Motion : a Graphic Portrayal of the Nature of Money and the American Monetary System. 11½ in. × 8½ in. (28·5 cm. × 21·5 cm.). Pp. xvii + 141. (New York : John de Graff, Inc., 1961.) 5·95 dollars.*

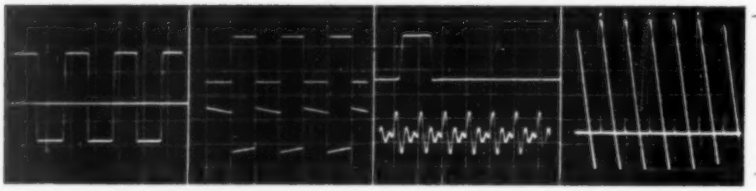
DUNNING, J. H., and THOMAS, C. J. British Industry : Change and Development in the Twentieth Century. 8½ in. × 5½ in. (21·5 cm. × 14 cm.). Pp. 232. (London : Hutchinson and Co. (Publishers), Ltd., 1961.) 30s. net.*

EDWARDS, Ronald S., and TOWNSEND, Harry (edited by). Studies in Business Organisation. (A Supplement to "Business Enterprise".) 8½ in. × 6 in. (22 cm. × 15·5 cm.). Pp. xxiii + 160. (London : Macmillan and Co., Ltd. ; New York : St. Martin's Press, Inc., 1961.) 25s. net.*

ELWELL, F. R. Science and the Farmer. 7½ in. × 5 in. (19 cm. × 12·5 cm.). Pp. 108 + 16 plates. (London : G. Bell and Sons, Ltd., 1961.) 15s. net.*

HILL, A. V. The Ethical Dilemma of Science and other Writings. 8½ in. × 5½ in. (21·5 cm. × 14 cm.). Pp. xiii + 395. (New York : Rockefeller Institute Press ; London : Oxford University Press, 1960.) 7.50 dollars ; 52s. net.*

PERLOFF, Harvey S., DUNN, Jr., Edgar S., LAMPARD, Eric E., and MUTH, Richard F. Regions, Resources, and Economic Growth. 10 in. × 6½ in. (25·5 cm. × 16·5 cm.). Pp. xxv + 716. (Baltimore, Md. : The Johns Hopkins Press ; London : Oxford University Pres, 1960. Published for Resources for the Future, Inc.). 96s. net.*



D31

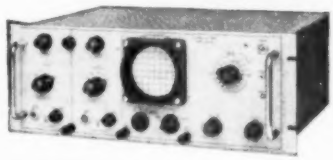
*D.31 double beam Serviscope**

D.C. amplifiers and slow speed time base (down to 5 sec/cm if necessary) are eminently suitable for servo work and similar applications. Fast rise time (.06μ sec) and high writing speed (10cm/μsec at maximum expansion) are essential for any work dealing with fast pulses or TV waveforms. The unique triggering arrangements enable complex waveforms to be examined in detail with complete accuracy of synchronisation. At this moment the D.31 is in use in the diverse fields of computer development and servicing, radar equipment, telemetering applications, closed circuit and broadcast TV, automatic telephone equipment . . . and is proving itself ideally suited to laboratory work where an oscilloscope has, of necessity, to be somewhat of a Jack of all trades.

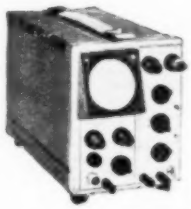
Potentialities per pound

Both per £ and per lb., each Serviscope offers greater flexibility, accuracy and reliability than any oscilloscope of comparable specification. A radical reassessment of design and production techniques has enabled smaller, lighter, instruments with many improved features to be offered giving a far higher performance than their low price would suggest.*

Weight 26 lbs. **£95**



DS1R Electrically identical, but designed for mounting in standard 19" racks.



S31 single beam oscilloscope has the same specifications with a single beam display. The original, highly successful 'Serviscope'.

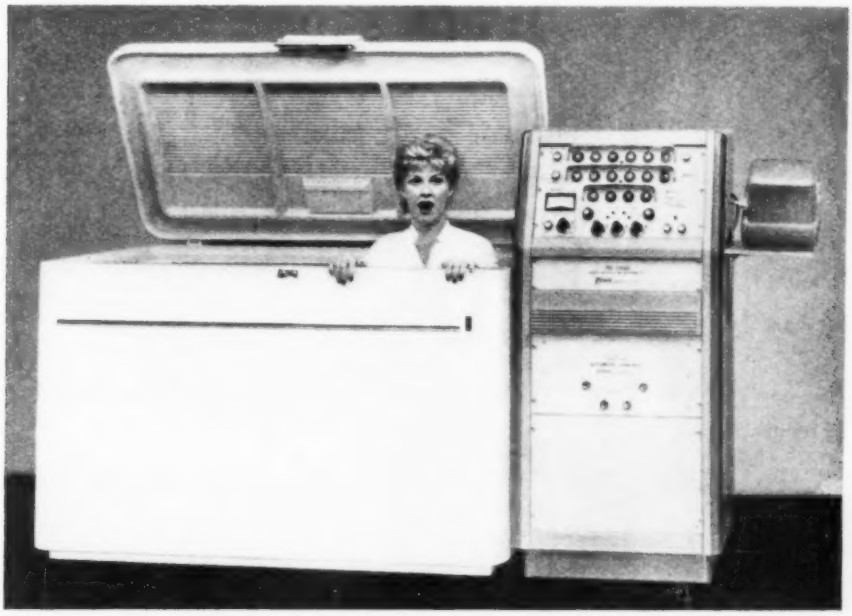
Weight 16 lbs. **Price £75.**

R.E.C.M.F. Exhibition, *Olympia*, *May 30th—June 2nd*, Stand No. 497, Grand Hall Gallery

* 'Serviscope' is the registered trade mark of Telequipment Ltd.

TELEQUIPMENT

Telequipment Limited, 313 Chase Road, Southgate, London, N.14. Tel: Fox Lane 1166



It's What's Inside That Counts!

If you are counting radioactive isotopes . . .

tritium, carbon-14, iodine-131, iron-59 or any other alpha, beta or gamma tracer isotope . . .

you should know about the latest transistorized instruments designed and manufactured by Packard.

Auto-Gamma System

Series 250A Automatic Scaler

Whether or not you are planning to purchase new equipment, you will be interested in our latest bulletins which show "what's inside" these instruments that makes them count so well . . . so reliably.

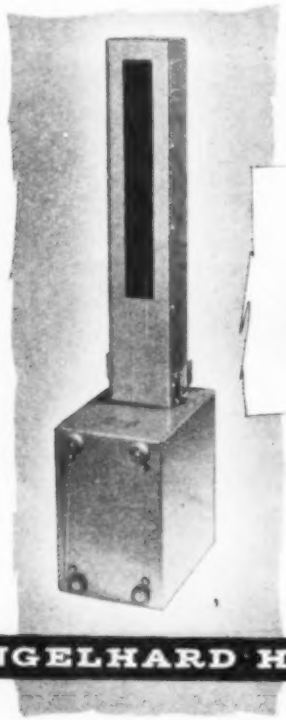
Write or telephone requesting new instrument bulletins.

TRI-CARB LIQUID SCINTILLATION SPECTROMETERS • AUTO-GAMMA SPECTROMETER SYSTEMS
FLOW DETECTORS • SCALERS • RATEMETERS

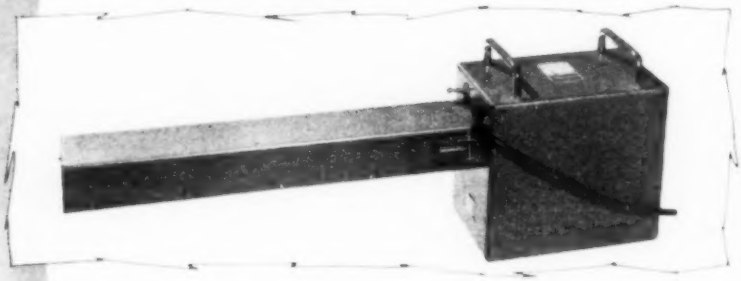
Packard Instrument Company, Inc.

BOX 428-P • LA GRANGE, ILLINOIS • Phone HUnter 5-6330

CHICAGO • ALBUQUERQUE • ATLANTA • BOSTON • LOS ANGELES • NEW YORK • PHILADELPHIA
PITTSBURGH • SAN FRANCISCO • WASHINGTON, D. C. • ZURICH • PARIS



The VERSATILE Chromatolite



Specially developed by Hanovia for Chromatography and fluorescence investigations involving short wave U.V. rays at 2537 A.U.
Can be used horizontally, vertically, on its side or facing upwards.
We shall be pleased to send you full details.

ENGELHARD HANOVIA LAMPS

(Dept. 102 59) BATH ROAD, SLOUGH, BUCKS. TEL: BURNHAM 500

ENDECOTTS
TEST SIEVES
For Accuracy!

POCKET INTERCHANGER SIEVES

'ENDROCK' TEST SIEVE SHAKER

TEST SIEVES
B.S. 410: 43 U.S. Standards and Tyler Equivalents

We operate a Recovering Service

Consistent mechanical action—
saves valuable time of skilled personnel

ENDECOTTS (FILTERS) LTD. Phone: LIBerty 8121/2/3
Dept. B Lombard Rd., London, S.W.19. Grams: Endfilt, London

MINERAL SPECIMENS

We announce a collection of mineral specimens, mainly crystalline, some loose, some upon their matrix.

Although we specialize in the supply of British minerals, our collection contains many foreign species.

Our complete mineral catalogue gladly sent on request.

THE MINERAL DEPARTMENT
RAYNER
100 NEW BOND STREET, LONDON, W.1
Grosvenor 5081

"I REALLY STARTED SEEING EYE TO EYE WITH THE PROF. the day he got us this new LEITZ ORTHOLUX"

"You mean on other things you didn't?"
"Well, a bit dogmatic. Nasty habit of thinking he's always right."
"And usually *being* right?"
"Precisely. But now I forgive him everything."
"Because of the Ortholux, of course."
"No less. This time he convinced the Faculty he was right. He invited them to support their proposition that this was a really important research project by letting him have the best microscope to go with it."
"A nice tactical touch."
"*And* he didn't stop at the microscope. He got the thing equipped with those magnificent flat field objectives and wide field eyepieces. Absolutely revolutionary! Then there's phase contrast . . ."
"Steady boy, I'm only a humble house surgeon."
"Sorry. If I may simplify, this is an act of professorial penance to obscure a thousand misdemeanours of the past."

a microscope by Leitz a product of thoughtfulness and skill

E. LEITZ (INSTRUMENTS) LTD, 30 Mortimer St, London, W.1

POLARIZING MICROSCOPE
WITH THREE-AXIS
UNIVERSAL STAGE
COOKE
M 7518
WITH M 7745

Cooke Troughton & Simms LTD
YORK ENGLAND

Stop Watches

for scientific and industrial use are supplied to research establishments and industrial organizations. Enquiries are welcomed.

Sectional catalogues and leaflets available:

Watches, stop watches and chronographs.
Recording apparatus.
Clocks, domestic and industrial.
Process timers and time interval meters.
Electrically controlled stop watches.

Repair Service

Watches, stop watches and clocks. Marine chronometers. Instruments.

Model 603 1/10th second escapement 'split hands' 30 minute recorder. NPL certificate if required.

CAMERER CUSS
Timing Division
Makers of good Clocks and Watches since 1788
at 54/56 NEW OXFORD STREET, LONDON, W.C.1
MUSeum 8968/9
Service and Repairs: MUSeum 2255. Our only other address: 91 Kingsway, W.C.2

TRANSIENT IMAGE BECOMES PERMANENT RECORD

with the new S & P direct-writing

OSCILLOGRAPH RECORDER

A highly-advanced and versatile unit with the important advantages of very high speed and sensitivity. Special pencil-type mirror galvanometers trace records on 6-in wide ultra-violet sensitive paper which requires no processing.

PERFORMANCE DETAILS

Permanent continuous or intermittent records can be made at frequencies from d.c. to frequencies in excess of 1,000 c.p.s. The system gives a well defined trace, at writing speeds above 12,000 in. per sec. Choice of 8 paper speeds, from 5 in. per min. to 150 in. per sec. 12 channels, but with 3 additional channels for time, event, datum reference lines, or for use as additional signal channels if desired. Matched amplifiers and power supply units can be supplied.

APPLICATIONS

Industrial, Scientific, Medical and Military . . . Because a transient tube image is replaced by permanent records for analysis, this unit will have special value for many purposes in universities and technical colleges. Other applications include: Stress analysis by electrical strain gauge techniques. Testing heavy electrical equipment. Records of electric power supply characteristics. Laboratory process analysis. Missile and gun performance testing, and general telemetery use. Cardio-vascular and respiratory investigation.

Please write now for details and Publication No. 33/0

SAVAGE AND PARSONS LIMITED

WATFORD · HERTFORDSHIRE · ENGLAND · Tel: WATFORD 26071

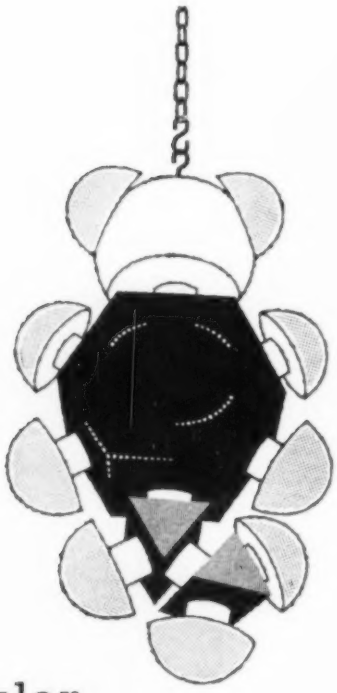
STATIC AND DYNAMIC STRAIN RECORDERS · RESISTANCE THERMOMETERS

TSA PR3A 1

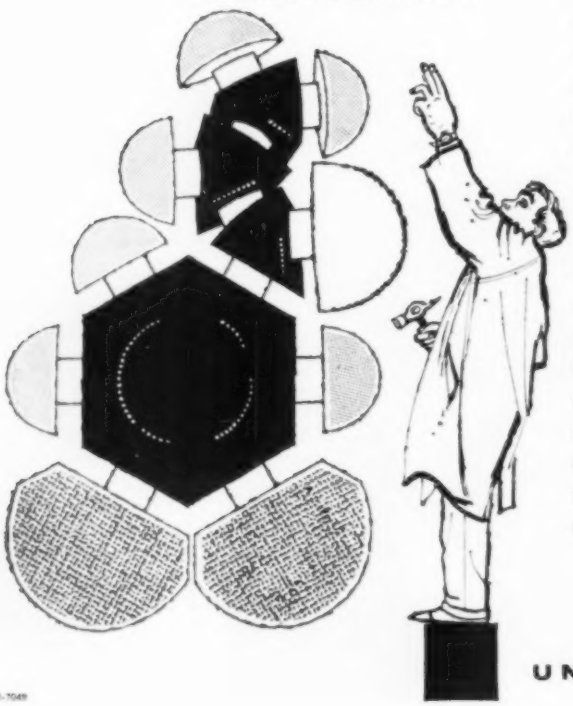
IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON, S.W.1.

ICI
GENERAL CHEMICALS DIVISION

SN3



molecular architecture



It is always interesting to study a natural organic compound, to note the ingenuity and specificity of its synthesis, and its ultimate fitness for purpose. Scientists cannot yet match nature in the specificity of her methods, but they can do so in ingenuity and occasionally excel her in fitness.

Take organic fluorescers, for example, of which many man-made varieties are better than the best natural product. Herschel, Brewster and Stokes, in their original work on fluorescence, used quinine sulphate. They were interested in the physical phenomenon. Knorr, a chemist, was more interested in the pharmacological action of quinine, and his studies of related heterocyclic nitrogen compounds led to the syntheses of the pyrazole and pyrazoline five-membered rings.

In so doing he paved the way also for more active fluorescers. Bowen has pointed to the importance of electron donors and acceptors in fluorescence, and the need for a conjugated system of Pi electrons only lightly coupled to the molecular lattice to limit the dissipation of resonant energy. Both he and Pringsheim have discussed heterocyclic compounds in this context and shown that rigid molecular structure and internal conjugation are conducive to fluorescence.

Pyrazole itself does not provide a suitable nucleus since the carbon-carbon double bond acts as an electron trap in the heterocyclic ring system, but diaryl pyrazolines are excellent fluorescers, and Kendall and Duffin, and Neunhoeffer and Rosahl, have made broad studies of the group. Unilever are active in the study of these fluorescers, and Chase and co-workers have made a close study of the relation between structure and fluorescent characteristics.

UNILEVER RESEARCH

UR2-7049

Esther Lederberg of the Department of Genetics, Stanford University.

All incubations were carried out under aerated conditions at 37° C. The mutant strains were grown from slants in a fortified medium[17] to which thymine (strain *W4516*) or purines (strain *W3687*) were added. Primary cultures of strains *B* and *B/r* were grown on mineral medium[18]. Secondary cultures employed mineral medium to which 2 per cent sulphanilamide was added to block *de novo* purine and pyrimidine synthesis. The sulphanilamide medium required supplementation with several other bases, vitamins and minerals. The purine and pyrimidine analogues under investigation were usually added at a level of 100 μgm./ml. Analogues studied to date include BU, IU, 5-fluorouracil (FU), thioguanine (TG), 2-aminopurine (AP), and 2,6-diaminopurine (DAP).

X-irradiation was carried out at 250 kV., 15 m.amp., 30 cm. distance, 0·25 mm. copper + 1·0 mm. aluminium filter, 1·10 mm. copper half-value layer, dose-rate 360–390 r./min. Cultures were collected by centrifugation, washed, suspended and diluted in phosphate buffer to concentrations of about 1×10^7 organisms/ml., and irradiated in 'Teflon' cups fitted in a 'Lucite' block, as described by Gunter and Kohn[19]. Ultra-violet irradiations were performed with an unfiltered low-pressure mercury lamp with a measured output of 16·6 ergs/sq. mm./sec. at 43 cm. distance. Samples were withdrawn at successive time-intervals from an open Petri dish buffer suspension. After irradiation, samples were appropriately diluted and plated on nutrient agar (fortified with thymine or adenine for the mutant strains) and incubated at 37° C. Colony counts at each radiation dose-level are expressed as a fraction of the viable counts of non-irradiated samples. Radiosensitivity is expressed in terms of the experimental/control slope ratios of dose – log survival curves.

DNA was isolated from aliquots of control and experimental cultures by differential chemical extraction; mixed nucleic acids by lysis with 2 per cent sodium lauryl sulphate. When necessary, RNA was removed by alkaline hydrolysis. BU incorporation into DNA was established by three different methods: cæsium chloride density gradient determination[20]; incorporation of radioactive ^{82}Br–BU (synthesized by Dr. Joseph P. Kriss[21]); and base hydrolysis and chromatography. TG incorporation was determined with the analogue labelled with sulphur-35. Detection of DAP incorporation into DNA required the use of carbon-14-labelled analogue.

The incorporation of ^{82}Br–BU into DNA was linear with time until the end of the phase of exponential growth, by which time there was 35–50 per cent replacement of thymine by BU. Stationary phase cultures showed further incorporation with a plateau at about 70 per cent replacement of thymine by BU. Base hydrolysis and chromatographic analysis of DNA from stationary phase cultures indicated 68 per cent replacement. The flotation density of the isolated DNA was 1·763 (control 1·712), corresponding to 70 per cent replacement of thymine by BU. There was little or no decrease of viability of organisms that incorporated BU through the log phase; but a rapid decrease in viability with further BU incorporation during stationary phase was noted. For this reason most of the radiation experiments were carried out on organisms collected during the log phase.

Strains *W4516* and *B/r* labelled with BU exhibited a striking enhancement of sensitivity to ultra-violet, the curves being essentially identical to those reported by Greer[14]. The thymineless mutant, strain *W4516*, showed a multi-hit type of X-ray dose-survival curve, with an extrapolation number which fluctuated somewhat but was usually in the range 1·5–2·0. When this organism was grown on BU, the shoulder of the X-ray survival curve narrowed appreciably, and in some instances vanished, while the slope of the linear portion of the curve exceeded that of the control curve by a factor of 1·8–2·2 in various experiments (Fig. 1). For the wild-type strains, the control curves of which were of the single-hit type, radiosensitization by BU yielded slope ratios of approximately 1·6–1·8 for strain *B/r* and 1·4–1·5 for strain *B* under log-phase conditions. Organisms grown on reciprocal 9 : 1 mixtures of thymine and BU exhibited responses intermediate between the extremes of 100 per cent thymine- or 100 per cent BU-grown cultures. Radiosensitization was a function of incubation time in the presence of BU, being undetectable after 2 hr. (8 per cent thymine replacement), barely detectable at 4 hr. (about 20 per cent replacement), and maximal by 8 hr. (approximately 40 per cent replacement). The possibility that some threshold level of BU incorporation is required merits further study in the time interval between 2 and 4 hr. When the thymineless mutant strain *W4516* was grown through log phase in BU, then diluted ten-fold and re-incubated in thymine long enough to permit one replication of DNA, the resulting organisms, containing DNA which was presumably labelled in only one strand with BU, exhibited a radiosensitivity intermediate between that of controls and fully BU-labelled cells. A somewhat greater loss of radiosensitivity has been reported in BUDR-labelled mammalian cells after one replication in the presence of thymidine[15].

In one experiment, IU-grown strain *W4516* cells exhibited conversion to a single-hit type of curve, but the slope was essentially identical to that of the controls. In the same experiment, cells grown on BUDR showed slightly greater radiosensitization than BU-grown cells, with slope ratios of 1·80 versus 1·35 relative to thymine-grown controls, respectively. The mere presence of the analogues in the culture medium, under conditions in which incorporation into DNA could not proceed (for example, in the absence of sulphanilamide) yielded radiation dose-survival curves identical with those of controls. In

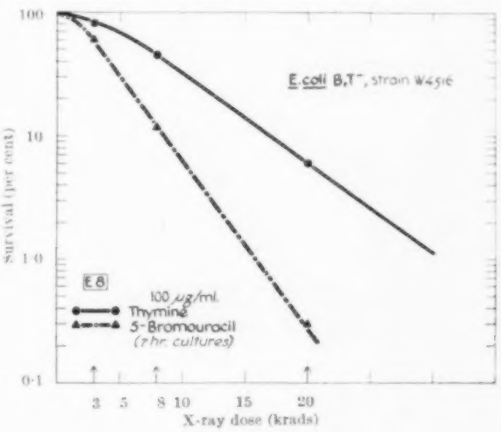


Fig. 1

limited trials to date, pre-incubation of strain *B/r* with 5-FU has revealed no radiosensitization. This analogue, unlike IU and BU, is incorporated into RNA, but not into DNA (ref. 22).

Thioguanine is incorporated into log-phase strain *B/r* to the extent of about 0·6 per cent, calculated on the basis of replacement of DNA guanine. Although the extent of incorporation is considerably less than that of BU at corresponding time-intervals, the degree of radiosensitization to both ultra-violet and X-rays was approximately the same (Fig. 2). Consistent with this observation is the finding (to be reported in detail in a separate paper) that aqueous solutions of TG were appreciably more sensitive than any of the natural bases to spectral degradation by ultra-violet, whereas BU was only slightly more sensitive than thymine. The spectral degradation of TG by X-rays was markedly more sensitive than that of guanine and essentially identical with the responses of BU and thymine. Since purines and pyrimidines are presumably incorporated into DNA more or less independently, the effect of combined BU and TG was studied in sulphanilamide-grown strain *B/r*. In the presence of TG, BU incorporation was markedly reduced, reaching a level of only 12 per cent thymine replacement, as compared with 70 per cent in the absence of TG. None the less, organisms which had incorporated both analogues into their DNA exhibited a further increase in X-ray sensitivity (slope ratio 2·95 versus 2·2 for TG or BU alone, Fig. 3).

Although most of the radioactivity of DAP labelled with carbon-14 incorporated into DNA of purine-deficient strain W3687 cells was in guanine and adenine, the incorporation of unchanged DAP to the extent of about 1 per cent was demonstrable by careful chromatographic separation from guanine in the presence of carrier DAP. Replicate experiments with this strain indicated a slight increase in radiosensitivity, with slope ratios in the range 1·15–1·25. There was a departure from linearity at higher dose-

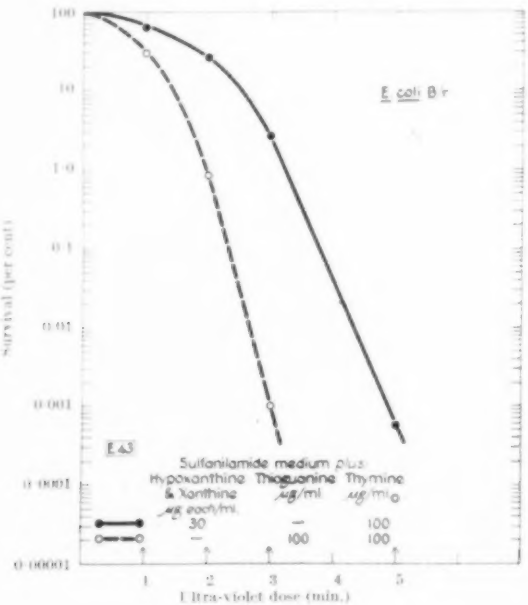


Fig. 2

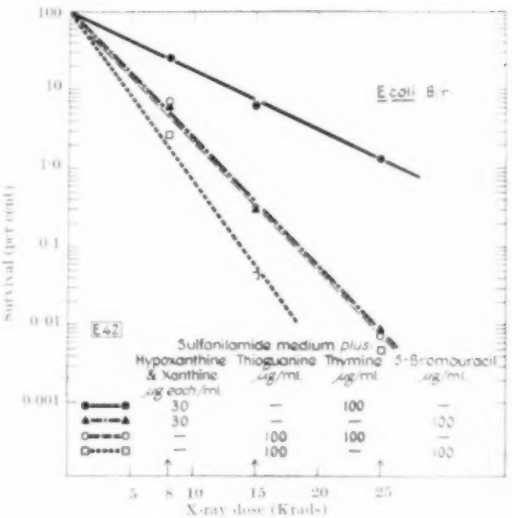


Fig. 3

levels, indicating the presence of a small proportion of cells which had failed to incorporate the analogue. In one experiment with AP in strain W3687, neither radiosensitization nor incorporation into DNA was demonstrable.

In summary, it appears that both ultra-violet and X-ray sensitivity of *E. coli* are enhanced when appreciable proportions of the natural bases of DNA are substituted by any of several purine and pyrimidine analogues. Analogues which fail to enter bacterial DNA (FU, AP) have to date failed to elicit this response. Based on relative extent of incorporation, TG is the most active radiosensitizing agent thus far reported, with BUDR, BU, IU, and DAP following in order of decreasing activity.

These investigations were aided by grants *C*-3352 and *C*-2896 from the National Cancer Institute, National Institutes of Health, U.S. Public Health Service. Analogues were obtained from the California Corporation for Biochemical Research, Los Angeles, California; ^{35}S-TG from Isotopes Specialties Company, Burbank, California.

[1] Alper, T., and Gillies, N. E., *J. Gen. Microbiol.*, **18**, 461 (1958).
[2] Alper, T., and Howard-Flanders, P., *Nature*, **178**, 978 (1956).
[3] Howard-Flanders, P., *Nature*, **180**, 1191 (1957).
[4] Patt, H. M., *Physiol. Rev.*, **33**, 35 (1953).
[5] Bacq, Z. M., *Acta Radiol.*, **41**, 47 (1954).
[6] Doherty, D. G., Brunett, jun., W. T., and Shapiro, R., *Rad. Res.*, **7**, 13 (1957).
[7] Dunn, D. B., and Smith, J. D., *Nature*, **174**, 305 (1954).
[8] Zamenhof, S., and Griboff, G., *Nature*, **174**, 306 (1954).
[9] Matthews, R. E. F., and Smith, J. D., *Nature*, **177**, 271 (1956).
[10] LePage, G. A., *Cancer Res.*, **20**, 403 (1960).
[11] Wacker, A., Kirschfeld, S., and Träger, L., *J. Molec. Biol.*, **2**, 241 (1960).
[12] Prusoff, W. H., *J. Biol. Chem.*, **226**, 901 (1957).
[13] Kaplan, H. S., and Tomlin, P. A., *Rad. Res.*, **12**, 447 (1960). Kaplan, H. S., Tomlin, P. A., and Smith, K. C., *Clin. Res.*, **9**, 107 (1961).
[14] Greer, S., *J. Gen. Microbiol.*, **22**, 618 (1960).
[15] Djordjevic, B., and Szybalski, W., *J. Exp. Med.*, **112**, 509 (1960).
[16] Witkin, E. M., *Proc. U.S. Nat. Acad. Sci.*, **32**, 59 (1946).
[17] Zamenhof, S., *et al.*, *J. Biol. Chem.*, **219**, 165 (1956).
[18] Lederberg, J., in *Methods in Medical Research*, **3**, 5 (Chicago, 1950).
[19] Ginter, S. E., and Kohn, H. I., *J. Bact.*, **71**, 571 (1956).
[20] Meselson, M., Stahl, F. W., and Vinograd, J., *Proc. U.S. Nat. Acad. Sci.*, **43**, 581 (1957).
[21] Kriss, J. P., Tung, L., Revesz, L., and Egloff, S., *Clin. Res.*, **9**, 107 (1961).
[22] Heidelberger, C., *et al.*, *Nature*, **179**, 663 (1957).

LETTERS TO THE EDITORS

ASTROPHYSICS

Solar Flare Effects in the *F* Region of the Ionosphere

ELEVEN years ago, Dieminger reported that the large solar flare of November 19, 1949, had a marked effect on the *F* region over Lindau, Germany[1]. A similar *F*-region effect was observed at Okinawa and probably at Singapore at the time of the outstanding flare of February 23, 1956[2,3]. In addition to being very large, these flares were notable in that they were two of the five flares that had occurred up to that time during which increases in sea-level cosmic ray had been observed. Yet, because the *F*-region effect had been detected at so few of the sunlit ionospheric sounding stations, some doubt remained as to the correct interpretation of these observations.

The purpose of this communication is to report two additional cases of *F*-region effects which were recently observed accompanying the two large solar flares that occurred at 1323 U.T. on November 12, 1960, and at 0207 U.T. on November 15, 1960. Because these flares were also followed by cosmic ray increases recorded at sea-level (flares number eight and nine in the series now numbering ten, the tenth having been observed on November 20, 1960), the connexion between the relatively few flares that are associated with the emission of these very high energy particles (≳2 BeV.) and apparent *F*-region effects is considerably strengthened. It is likely that the *F*-region effects are not caused by the cosmic-ray particles themselves but rather that flares associated with the emission of these very high energy particles are also unusual in their photon radiation. However, it should be noted that, in the course of this work, several apparently similar, but considerably smaller, *F*-region effects have been found in association with solar flares that were not observed to be followed by sea-level cosmic ray increases or polar cap absorption events.

Fig. 1 shows the variation of *F*-region maximum electron density, as determined from observations of the vertical-incidence penetration frequency, around the time of the two November 1960 flares and the two earlier flares discussed above. It can be seen that increases of about 20–50 per cent in maximum electron density occurred during the course of each flare. Examination of the soundings data taken on November 12, 1960, at other sounding stations along the east coast of the United States and in the Caribbean suggests that the *F*-region effect may have extended over the entire area, but at no other station was the effect as definite as at San Salvador, British West Indies, possibly due to the fact that the rapid diurnal increase in electron density was occurring at most of the stations at the time of the flare. Fortunately, however, an independent observation of the *F*-region effect associated with the flare of November 12, employing a different technique, is also available. Since January 1960, an experiment has been going on at

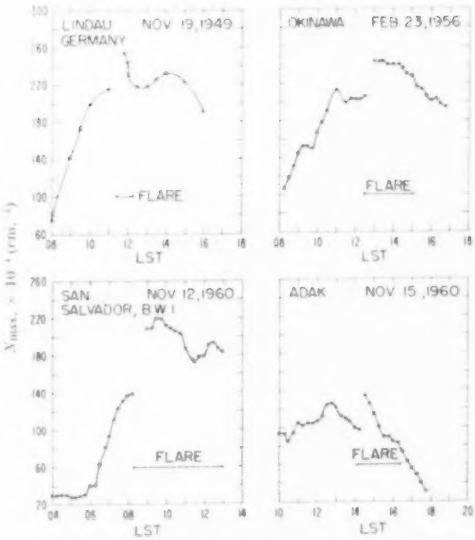


Fig. 1. Variations in *F*-layer maximum electron density during four cosmic ray-associated solar flares

the National Bureau of Standards that involves the study of oblique incidence propagation characteristics by means of recordings of frequency changes on high-frequency transmissions[4]. At the time of the November 12 event, recordings were being made in Boulder, Colorado, of the precise frequency of the *WWV*-20 Mc./s. transmission from Washington, 2,370 km. away. The effect shown (Fig. 2), which begins within about a minute of the time of commencement of the flare, can be interpreted as a 22 ± 5 km. lowering of the reflexion height at the midpoint of the path. (Note that no other effect, comparable in magnitude, has been observed in the 14 months since recording began.) While it was not possible to obtain meaningful electron density profiles from the November 12 San Salvador ionograms, due to large *D*-region absorption effects, it was possible to deduce profiles from the soundings taken at Adak during the November 15 event. Examination of the Adak profile data, shown in Fig. 3, reveals that the height of the plasma frequency-level of 6 Mc./s., which approximates to the

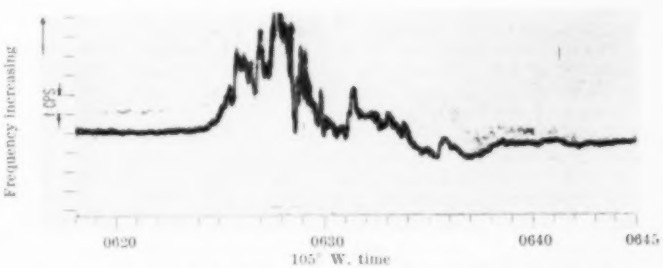


Fig. 2. Variations in the frequency of *WWV*-20 Mc./s. signal as recorded at Boulder, Colorado, November 12, 1960. The flare began at 0623 and the increase in sea-level cosmic ray at about 0640 (Deep River, Ont.)

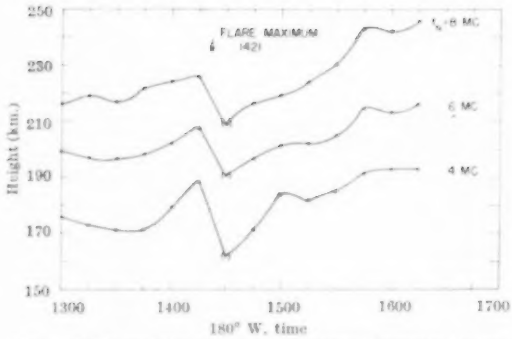


Fig. 3. Height variation of several fixed plasma frequencies during the solar flare of November 15, 1960; Adak, Alaska

equivalent vertical incidence frequency for 20 Mc./s. propagation over a 2,370-km. oblique path, decreased about 18 km. during this flare event, an effect of the same magnitude as that observed on the records of change in frequency during the November 12 event.

As mentioned above, less well-marked *F*-region effects that may be flare-associated were observed at several other locations during the November 1960 events. However, many sunlit hemisphere stations, with good *F*-region observations throughout most of the duration of the flares, show no change in *F*-region maximum electron density. A more complete examination of vertical soundings data obtained at sunlit locations during flares having sea-level cosmic ray increases is now under way.

R. W. Knecht
K. Davies

National Bureau of Standards,
Boulder, Colorado.

[1] Dieminger, W., and Geisweid, K. H., *J. Atmos. Terr. Phys.*, **1**, 42 (1950).
[2] Shapley, A. H., and Knecht, R. W., *Inst. Rad. Eng. Trans. AP.*, **5**, 326 (1957).
[3] Minnis, C. M., and Bazzard, G. H., *Nature*, **181**, 690 (1958).
[4] Watts, J. M., and Davies, K., *J. Geophys. Res.*, **65**, 2295 (1960).

PHYSICS

Effects of High Pressure on Glass : a Possible Piezometer for the 100-Kilobar Region

The measurement of pressures of the order of 10,000–200,000 bars and upward on uniaxial pressure transmitting devices is a formidable problem. At present, inter-laboratory comparison of results obtained at ultra-high pressures is not satisfactory. The availability of a convenient pressure calibration substance that is useful over a wide temperature-range, and the agreement on a satisfactory scale of pressure based on this calibration substance, are imperative for future work.

To date, the only convenient high-pressure calibration substances for extreme pressure devices depend on the temperature-dependent phase transitions which occur in some metals. This is unsatisfactory, since it allows only point-wise calibration over a limited range of pressures and is limited to the room-temperature 'fixed' points.

Bridgman and Simon[1] have reported that silica glass could, above a threshold pressure of about 100,000 atmospheres, be made permanently more dense, and at pressures of about 200,000 atmospheres this increase in density amounted to about 6–7 per cent. In an attempt to check pressure apparatus in this laboratory against Bridgman's data, some very surprising findings were encountered.

The apparatus used has been described by Dachille and Roy[2] and is similar to that employed by Bridgman and Simon[1]. Automatically regulated pressure was applied to two opposed anvils of the Bridgman type by means of a hydraulic press. The pressure was calculated on the basis of the total force developed by the ram of the press and the area of the anvil face after removal of pressure. The sample was heated and its temperature automatically regulated by means of a split external furnace. A basic difference in procedure used by us was the use of powdered glass instead of a continuous disk.

The effect of pressure on the density and refractive index of silica glass was found to be much greater than that reported by Bridgman and Simon[1]. Further, the change in density was found to be a continuous function of pressure above 20,000 atmospheres at room temperature. No threshold effect was observed at 600° C. The density of silica glass, which has a normal refractive index of 1·458, could be increased by a pressure of 150,000 atmospheres at room temperature to a form with a refractive index as high as α-quartz, namely, 1·54 (see Fig. 1). The changes achieved by Bridgman and Simon[1] at a reported pressure of 200,000 atmospheres could be achieved at pressures as low as 55,000 atmospheres at room temperature.

The effect of temperature is also very important. Silica glass which has been subjected to 40,000 atmospheres at 25° C. has an index of refraction, after returning to ambient conditions, of 1·48, whereas the index of the glass subjected to 40,000 atmospheres pressure at 500° C. has an index of refraction of 1·50 under ambient conditions.

For each pressure and temperature there is a pseudo-equilibrium volume for the silica glass. This volume is attained in less than 15 sec. and does not alter after several days at pressures and at temperatures (less than 600° C.) less than those initially applied.

The compressed silica glass is quite stable under ambient conditions. Samples of the compacted silica glass have been kept undesiccated for 1½ years without any noticeable change in index of refraction. Further, the glass can be kept for a week at 600° C. at atmospheric pressure without undergoing any noticeable relaxation. Glasses compacted by the uniaxial device show a spread of about ±0·005 index of refraction unit. This is probably a result, as Bridgman

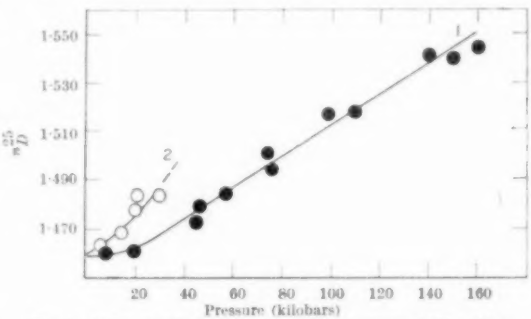


Fig. 1. Index of refraction of the quenched phase of silica glass as a function of the pressure of the run: (1) at 25° C.; (2) at 600° C.

and Simon suggest, of the uniaxial nature of the pressure-transmitting device. Glasses subjected to 10,000 atmospheres argon pressure (hydrostatic pressure) in a bomb appear homogeneous when examined by the standard immersion-oil technique (that is, within ± 0·001 unit), with indices falling on the same curve.

The continuous compaction of glass as a function of pressure is not unique to silica glass. Similar results of somewhat lesser magnitude have been observed in germanium oxide, boron oxide, as well as silver phosphate and 'window' glass. A detailed report on the effects of pressure and temperature on these glasses will be given elsewhere[3].

In view of the observed continuous increase of density of silica glass as a function of both temperature and pressure, it is proposed that the refractive index of silica glass be used as a piezometer. Silica is particularly inert and could be mixed with many samples to provide a check on the actual pressure and/or temperature of a run. It is suggested that it would be quite valuable if several laboratories interested in high-pressure measurements determined independently the effect of pressure and temperature on the refractive index of silica glass. Perhaps a satisfactory pressure-scale could then be agreed upon.

This investigation has been supported by a grant to the University for fundamental studies in defect solids by the Bausch and Lomb Optical Company. We are much indebted to our colleague, Dr. F. Dachille, for help with equipment and ideas.

Rustum Roy
H. M. Cohen

Department of Geophysics and Geochemistry,
Pennsylvania State University,
University Park, Penn.

[1] Bridgman, P. W., and Simon, I., *J. App. Phys.*, **24**, 405 (1953).
[2] Dachille, F., and Roy, R., *Z. Krist.*, **111**, 451 (1959).
[3] Cohen, H., and Roy, R., *J. Amer. Cer. Soc.* (in the press).

Estimation of Dynamic Modulus and Dynamic Yield Stress for 'Perspex'

It has been found that a steel ball dropped on to a thick flat plate of 'Perspex' produces an electrostatic charge over the contact area. This effect has been investigated with the view of developing a simple method for estimating the dynamic modulus and dynamic yield stress.

The technique for determining modulus was as follows: A cylindrical 'Perspex' rod 2·54 cm. diameter and 30 cm. long with polished flat ends was supported in a horizontal position. One end was placed against a fixed steel plate and a 1-cm. thick 'Perspex' end-piece was wrung on the other end with 'Vaseline'. A clean steel ball of diameter 3·2 cm. was suspended as a simple pendulum, so that on release from a given height, h cm., impact took place on the end-piece. A fine wire connected the ball to an oscilloscope amplifier which had a high resistance across the input. The voltage–time record showed that as the ball approached the polymer surface, it became charged by induction due to the surface electrostatic charge which is readily built up on 'Perspex'. In close proximity to the polymer the ball began to discharge, but on contact, the rate of induction decreased rapidly so that the potential of the ball fell below a minimum discharge potential resulting in a marked decrease in rate of discharge. However, once good contact had been established between ball and polymer, the rate of discharging increased until contact was broken when the process ceased. The duration of contact could thus be obtained from the oscilloscope record. For an impact velocity of 77 cm. sec.$^{-1}$ the measured duration of contact, t, was $37{\cdot}8 \times 10^{-5}$ sec. According to the Hertz[1] theory:

$$t = \frac{2{\cdot}94}{v^{1/5}}\left(\frac{5}{4}\frac{m}{n}\right)^{2/5}$$

where m is the mass of the ball, v the ball velocity on impact and n is given by:

$$n = \frac{4\pi\sqrt{R}E_1^2E_2^2}{3[(1-V_1^2)E_2 + (1-V_2^2)E_1]^2}$$

The quantities E_1, E_2, V_1 and V_2 are the Young's moduli and Poisson's ratios of steel and 'Perspex' respectively. The radius of the ball is denoted by R. Putting the above-measured value of t in the equations with values of E_1 and V_1 given by Davies[2] and V_2 given by Davies and Hunter[3], resulted in a dynamic Young's modulus (E_2) of $5{\cdot}3 \times 10^{10}$ dynes cm.$^{-2}$ for 'Perspex'. A different form of ball impact experiment by Tillet[4] using a 0·63-cm. diameter ball at a velocity of 90 cm. sec.$^{-1}$ gave with the Hertz calculation a modulus of $5{\cdot}4 \times 10^{10}$ dynes cm.$^{-2}$. These dynamic values compare favourably with the 'static' value of $1{\cdot}8 \times 10^{10}$ dynes cm.$^{-2}$ computed from Kolsky's[5] 'static' stress–strain curve and the dynamic moduli of $6{\cdot}8 \times 10^{10}$ (ref. 5) and $6{\cdot}0 \times 10^{10}$ dynes cm.$^{-2}$ (ref. 3), obtained at very high rates of stressing by pressure-bar methods.

Attempts have also been made to measure the diameter of the maximum indentation. A specimen was impacted and held over a tray of lycopodium powder and gradually lowered towards it until a quite distinct circular patch of powder had been attracted to the impact area. It was then assumed that the diameter of the powder patch d_p was equal to the diameter of maximum indentation d_e given by Hertz as:

$$d_e^3 = 6PR\left(\frac{1-V_1^2}{E_1} + \frac{1-V_2^2}{E_2}\right)$$

where P is given by:

$$P = \pi^2\left(\frac{5mv^2}{4n}\right)^{3/5}$$

There was a range of values of d_p for a given height of impact, but it seemed reasonable to suppose that it was the maximum value of d_p which was required. The maximum values of d_p obtained using an impactor of diameter 3·8 cm. at impact velocities in the range 58–310 cm. sec.$^{-1}$ gave calculated moduli in the range 8×10^{10} $6{\cdot}3 \times 10^{10}$ dynes cm.$^{-2}$. As will be seen from the previous paragraph, these values of modulus are impossibly large; they should not be greater than moduli obtained by pressure-bar methods. Thus it must be concluded that $d_p < d_e$.

The above conclusion and the fact that the stresses vary over the contact area are used to estimate the dynamic yield stress. It is assumed that during impact the ball discharges most efficiently where really good contact is made. Thus powder is primarily attracted where plastic yielding has occurred. Hence maximum values of d_p may correspond to a yield stress of the material. There may be other effects involved, but the above is assumed to predominate.

To calculate the yield stress corresponding to a maximum of the ratio d_p/d_e for a given h, where d_e was calculated using the modulus $5{\cdot}3 \times 10^{10}$ dynes cm.$^{-2}$, the Guest–Mohr hypothesis of elastic failure was taken in conjunction with Huber's[6] equations,

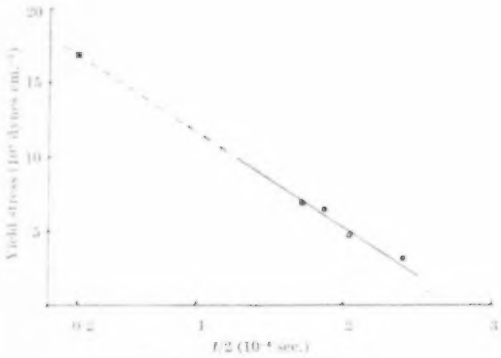


Fig. 1. Estimated yield stresses

which were then solved using a value of 0·35 for Poisson's ratio to give solutions of a graphical form described by Davies[2]. For values of h ranging from 48 cm. to 2 cm. the values of dynamic yield stress obtained were $6{\cdot}9 \times 10^8$–$3{\cdot}1 \times 10^8$ dynes cm.$^{-2}$. A straight-line plot was obtained for dynamic yield stress against half the duration of contact, $t/2$, given by the Hertz calculation with the modulus $E_2 = 5{\cdot}3 \times 10^{10}$ dynes cm.$^{-2}$. A typical set of results is shown in Fig. 1. Extrapolating the line to $t/2 = 0{\cdot}2 \times 10^{-4}$ sec., which is approximately the time to reach maximum stress in the pressure-bar experiments[3,5], gave a yield stress of $16{\cdot}9 \times 10^8$ dyne cm.$^{-2}$. Thus, assuming 'Perspex' behaves as a Hookean solid at pressure-bar rates of stressing, a yield stress of about $16{\cdot}9 \times 10^8$ dynes cm.$^{-2}$ should be observed. The dynamic stress–strain curve of Kolsky[5] does not show this, but the more recent results of Davies and Hunter[3] show a linear stress–strain curve up to a yield stress of approximately $16{\cdot}6 \times 10^8$ dynes cm.$^{-2}$. Thus the present simple technique may be of value in predicting high stress-rate behaviour.

A more detailed account of the above experiments for 'Perspex' and additional results for a number of other polymers will be published elsewhere.

John Roberts

Ministry of Aviation
Explosives Research and
Development Establishment,
Materials Research Laboratories,
Waltham Abbey,
Essex.

[1] Timoshenko, S., and Goodier, J. N., *Theory of Elasticity*, 383 (1951).
[2] Davies, R. M., *Proc. Roy. Soc.*, A **197**, 421 (1949).
[3] Davies, E. D. H., and Hunter, S. C. (unpublished War Office Report, 1960).
[4] Tillet, J. P. A., *Proc. Phys. Soc.*, **67***B*, 677 (1954).
[5] Kolsky, H., *Proc. Phys. Soc.*, **62***B*, 676 (1949).
[6] Huber, M. T., *Ann. Phys. Lpz.*, **14**, 153 (1904).

Packing of Spheres

In connexion with Bernal's theory of liquids, Scott[1] has determined the packing density of equal spheres by experiments with steel balls. In this laboratory we were interested in the dense random packing of beads of ion-exchange resins. Although particles of ion-exchange resins may vary in diameter from 1·3 mm. to 0·03 mm. or less, if the ratio of the diameters of the larger to the smaller beads in any batch exceeds 3 or 4, segregation may occur when the beads are backwashed or allowed to settle under water. If the ratio exceeded 6·5, it would be possible for the smallest spheres to fit into spaces between close-packed spheres of the largest diameter and so increase the packing density; but, if the problem is limited to the smaller ratios which occur in practice, only holes and not spaces can be filled by the smaller beads and the packing density should be 0·64–0·74.

The beads were sieved and packed under water, and to avoid peripheral errors at least 50,000 beads were taken for each determination. Narrow fractions with few irregular particles had packing densities close to 0·64. The value obtained for the most regular narrow fraction (irregular particles <4 per cent) was 0·63(8), in good agreement with Scott's extrapolated value of 0·63(7) for equal spheres. In this fraction the mean deviation from the mean diameter was 10·5 per cent. Wider fractions had increased packing densities, and a value of 0·66(7) was obtained for a fraction with mean deviation from the mean diameter of 23 per cent. Even higher values were obtained by mixing in various proportions beads of mean diameter 0·09 mm. with beads of mean diameter 0·31 mm. The smaller and larger beads alone each had packing densities of 0·66, but the packing density of the mixture reached a maximum of 0·70(5) when the proportion of the smaller beads was about 30 per cent of the mixture. Most batches of ion-exchange resin contain irregular fragments produced by the shattering of some of the beads, and these fragments probably affect the packing more than do rounded particles that are not truly spherical. The packing density of crushed resin was found to be 0·54 for particles of similar size. When various proportions of irregular particles were mixed with spheres of the same average size, the packing density remained at 0·64 until 10 per cent by intrinsic volume of irregular particles had been added. Thereafter the packing density decreased in proportion to the percentage of irregular particles in excess of 10 per cent.

J. R. Parrish

National Chemical Research Laboratory,
South African Council for Scientific and Industrial Research, Pretoria.

[1] Scott, G. D., *Nature*, **188**, 908 (1960).

GEOLOGY

Potassium–Argon Ages of the Dartmoor and Shap Granites using the Total Volume and Isotopic Dilution Techniques of Argon Measurement

Early in 1960, J. L. Kulp and others reported potassium–argon and rubidium–strontium ages for a number of granites from Great Britain and Eire[1]. The argon measurements were made at the Lamont Geological Observatory by the isotopic dilution technique, and the rubidium–strontium determinations were made at Oxford and Harwell. Some of the rocks examined, including the Shap and Dartmoor granites, had been measured by Mayne *et al.*[2], using the total volume technique for measuring the argon. There was a serious discrepancy between the potassium–argon measurements reported in these two communications, the results obtained by Kulp *et al.* being in agreement with the rubidium–strontium data (Table 2).

In this communication the results of new potassium–argon measurements on the Shap and Dartmoor granites, using both total volume and isotopic

Table 1. New Potassium Argon Ages

Mineral	Sample No.	K (per cent)	Argon technique	Radiogenic argon (std. c.c./gm. $\times 10^4$)	Atmospheric argon (per cent)	δV (per cent)	δt	Age (million years)
Dartmoor granite biotite		6·78	Total volume (Cambridge)	0·762	5·4	1·4	2·45	263
			"	0·766	2·4	0·6	2·47	264
			"	0·758	2·8	0·5	2·44	262
" "	20503 (I)	7·03	Isotopic dilution (Oxford)	0·835	18·5			276 ± 15
" "	20503 (IV)	6·65		0·756	36			265 ± 14
" "	20503 (II)	6·61	Total volume (Oxford)	0·734	13·5			260
" "	20503 (III)	5·89		0·667	14·0			265
Shap granite biotite	20512	6·47	Total volume (Cambridge)	1·154	2·6	0·3	3·62	401
				1·176	3·6	0·3	3·67	408
			" "	1·152	6·3	0·4	3·61	401
			" "	1·150	3·6	0·4	3·65	400
" "	"	6·42	Isotopic dilution (Oxford)	1·055	12·2			374 ± 20
				1·147	12·5			404 ± 20
			" "	1·091	12·7			386 ± 13
			" "	1·099	8·8			387 ± 13
			" "	1·083	15·0			381 ± 12
" "	7680	6·28	Total volume (Oxford)	1·072	13·5			405
" "	7682	6·46		1·177	12·5			419

Decay constants: $\lambda_\beta = 4{\cdot}72 \times 10^{-10}$ yr.$^{-1}$, $\lambda_e = 0{\cdot}584 \times 10^{-10}$ yr.$^{-1}$. Isotopic abundance of $^{40}K = 0{\cdot}0119$ atom per cent.
δV = percentage standard deviation in volume of radiogenic argon due to uncertainty in isotopic ratio of the specimen.
δt = error due to a 1 per cent error in proportion of K_2O or volume of radiogenic argon.

dilution techniques, are reported. The total volume measurements were carried out at Cambridge on newly developed apparatus, and at Oxford on the apparatus employed previously by Mayne *et al.* The isotopic dilution measurements were made at Oxford.

The total volume apparatus used at Oxford is similar to that described by Thomson and Mayne[3]. The apparatus used for the isotopic dilution measurements is a bakeable glass system which will be described elsewhere. Aliquots of argon-38 were prepared by a method similar to that of Wasserburg and Hayden[4], and calibrated by mixing with known amounts of spectroscopically pure argon. The accuracy of this system of argon measurement was checked from time to time by measuring the argon content of the reference biotite *B*.3203 supplied by Dr. P. M. Hurley of the Massachusetts Institute of Technology. The results of three measurements differed by 0·2–1·5 per cent from the mean of the American measurements. Duplicate determinations on younger materials suggest, however, that the accuracy is ± 3 per cent for the more recent measurements quoted in this communication, and rather more for the earlier ones.

The Cambridge apparatus used in the extraction and purification of argon is built mainly of stainless steel. It is small in size, and is connected directly to the mass spectrometer, which makes it easy to operate and reduces the likelihood of loss of gas by absorption, or the presence of small leaks which would add to the volume of gas finally measured. For successful total volume work both these troubles must be avoided, and also the McLeod gauge on which the volumes are measured must be accurately calibrated. This has been done in three ways:

(1) By the measurement of accurately known volumes of argon of different sizes, made up from spectroscopically pure argon using a gas pipette.

(2) By introducing samples of air from containers of known volume filled at a measured temperature and pressure.

(3) By measuring argon liberated by fusing the reference sample, *B*.3203.

Results from these experiments were consistent to about 1 per cent, which besides giving a reliable calibration of the McLeod gauge, indicated that the loss of argon by absorption was negligible, and that the method of purification of the gas was adequate.

For the work in both Oxford and Cambridge the potassium determinations were made by flame photometric methods. Each determination at Cambridge is the average of six analyses, and at Oxford the average of four. The accuracy of the Cambridge measurements is estimated to be ± 1 per cent, and of the Oxford ones ± 2 per cent.

The results of the new determinations are given in Table 1. Their mean values, weighing all determinations equally, are 265 ± 5 million yr. for the Dartmoor granite and 397 ± 8 million yr. for the Shap. In Table 2 these are compared with the corresponding results from the earlier reports. The new figures are in good agreement with both the potassium–argon and the rubidium–strontium ages of Kulp *et al.* (except that the difference between the new age for the Shap granite and the rubidium–strontium age slightly exceeds the uncertainties given). They confirm that the results of Mayne *et al.* are too high, particularly for the Shap granite. The reason for this is not known.

Table 2. Comparison with Earlier Results

Reference	Method	Age of Dartmoor granite (million yr.)	Age of Shap granite (million yr.)
Mayne *et al.* (ref. 2)	K/Ar. total volume	298*	465–499*
Kulp *et al.* (ref. 1)	K/Ar. isotopic dilution	271 ± 5	391 ± 7
Kulp *et al.* (ref. 1)	Rb/Sr	277 ± 5	381 ± 7
This work	K/Ar. both techniques	265 ± 5†	397 ± 8†

* Recalculated values.
† Error is twice standard deviation of mean.

The differences in the levels of contamination by atmospheric argon found in the two laboratories (Table 1) arise mainly from the use at Oxford of graphite crucibles, which have a large surface area for absorption of gas, while molybdenum crucibles are used at Cambridge.

In the figures obtained for the argon content of the Shap sample 20512 there is some evidence for a small systematic difference between the results by the two techniques. However, this is not large enough to be investigated easily at separate laboratories. The Cambridge apparatus is being modified to permit both techniques to be used on the same sample of gas.

It may be concluded from these results that the total volume technique can give good results on materials of Palæozoic age. The chief limit to its accuracy is the error in reading the McLeod gauge. The possibility of incomplete purification, however, must always be borne in mind, since the amount and composition of the contaminating gases which are evolved when a sample is fused are both variable. These limitations become less important for older rocks, and in our experience there seems to be little to choose in most respects between the two methods for work on Palæozoic and earlier materials. In general, however, it is considered that the isotopic dilution technique is preferable, since its accuracy can be maintained for much younger samples.

We wish to thank the Department of Scientific and Industrial Research for its financial support for these projects, and Prof. L. R. Wager and Sir Edward Bullard for their interest and encouragement.

M. H. Dodson
J. A. Miller
D. York *

Department of Geodesy and Geophysics,
University of Cambridge,
and
Department of Geology and Mineralogy,
University of Oxford.

* Present address: Department of Physics, University of Toronto.

[1] Kulp, J. L., Long, L. E., Giffin, C. E., Mills, A. A., Lambert, R. St. J., Giletti, B. J., and Webster, R. K., *Nature*, **185**, 495 (1960).
[2] Mayne, K. I., Lambert, R. St. J. L., and York, D., *Nature*, **183**, 212 (1959).
[3] Thomson, S. J., and Mayne, K. I., *Geochim. Cosmochim. Acta*, **7**, 169 (1955).
[4] Wasserburg, G. J., and Hayden, R. J., *Geochim. Cosmochim. Acta*, **7**, 51 (1955).

Karroo Igneous Activity and Tectonics in South-East Southern Rhodesia

During the period 1959–60 the work of the Research Institute of African Geology on Karroo igneous activity in Southern Rhodesia was extended to include the suite of Karroo igneous rocks which lie between the Lundi and Sabi Rivers some eighty to ninety miles to the north-east of those described by Cox *et al.*[1] (Fig. 1*a*). It is hoped to publish the detailed results of the work on this area soon.

Between the Sabi and Lundi Rivers the geological sequence is identical with that to the south-west. Basement gneisses, schists and quartzites of the east-north-east trending Limpopo Orogenic Belt[2] are unconformably overlain by Karroo sediments[3], and these in their turn underlie a considerable thickness of Karroo volcanic rocks.

The Karroo lavas in this region are estimated to be about 13,000 ft. thick and have a uniform dip of 7–10° to the south-east. They may be divided into a lower group of olivine-rich basalts and an upper group of more tholeiitic basalts in which olivine is noticeably scarce or absent. The ignimbrites, which characterize the uppermost part of the volcanic succession in the Nuanetsi District[1], are absent or overlain by later formations.

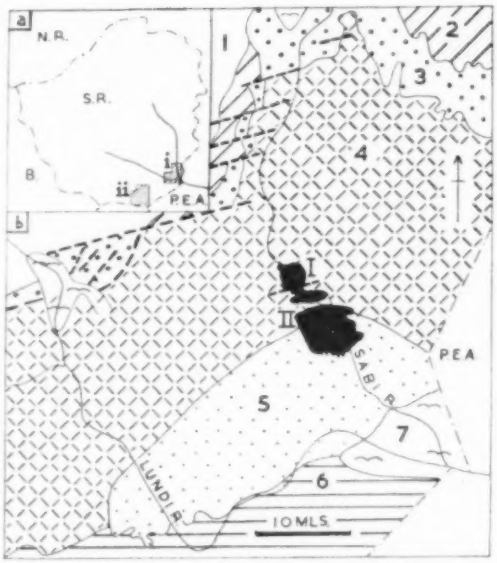


Fig. 1. (*a*) *N.R.*, Northern Rhodesia; *B*, Bechuanaland; *P.E.A.*, Portuguese East Africa; i, area shown in (*b*); ii, area described by Cox *et al.* (ref. 1). (*b*) 1, Basement Complex; 2, Umkondo System; 3, Karroo sediments; 4, Karroo basalts; 5, Main Granophyre; 6, Cretaceous; 7, Alluvium; I, Mutandawhe Complex; II, Chiwonje Complex

The extrusion of this thick sequence of lavas in the Sabi-Lundi area was followed by the intrusion of a series of rocks mainly of granitic affinities. Apart from a small horizontal tonalite body situated to the south-east of Mutandawhe, the earliest of these intrusions was a large sheet of porphyritic granophyre, the intrusion of which was localized at, or near, the upper limit of the basalts. This granophyre has an areal extent of 500 sq. miles and crops out from beyond the Lundi River in the south-west to beyond the Sabi River in the north-east (Fig. 1*b*); it can be correlated with the Main Granophyre of the Nuanetsi Area[1].

Subsequent phases of Karroo igneous activity are represented by two intrusive complexes in the Lower Sabi Valley. Mutandawhe, the more northerly of the complexes, is composed of granites and syenites and is characterized by a series of ring intrusions, but the Chiwonje complex to the south is composed entirely of granites which are intruded in part concordantly and in part discordantly. The rocks of these complexes have been responsible for copper, lead and tungsten mineralization in the surrounding basalts.

The final phase of igneous activity in the area is represented by a series of minor acid and basic intrusions.

In the southern part of the area the Main Granophyre and lavas are overlain by the conglomeratic basal member of a sedimentary series presumed to be Cretaceous in age. This latter group is in outcrop continuity with the post-Karroo sediments of the Nuanetsi area.

Structurally, the rocks as a whole overlie the east-north-east trending Limpopo Orogenic Belt[3,4], and the Chiwonje and Mutandawhe Complexes lie at the intersection of this belt with the southward projection

of the Sabi Valley Fault[5]. The influence of the Limpopo Orogenic Belt during post Pre-Cambrian times has been noted by Dixey[2] and is further suggested by the many faults which affect the Karroo rocks and which strike parallel to the orogenic belt.

D. N. Wood

Research Institute of African Geology,
University of Leeds.

[1] Cox *et al.*, *Nature*, **190**, 40 (1961).
[2] Dixey, F., "Vertical Tectonics in the East African Rift Zone", *Rep. Twentieth Intern. Geol. Cong., Mexico* (1956).
[3] Holmes, A., and Cahen, L., *Acad. Royale des Sciences Coloniales*, Nouv. Sér., **5**, fasc. 1, 102 (1957).
[4] Macgregor, A. M., "Pre-Cambrian Formations of Tropical Southern Africa", *Rep. Nineteenth Intern. Geol. Cong., Algeria* (1953).
[5] Mennell, F. P., *Trans. Geol. Soc. South Africa*, **22**, 68 (1920).
[6] Swift *et al.*, The Geology of the Lower Sabi Coalfield, *Southern Rhodesia Geological Survey*, Bull. No. 40 (1953).

CHEMISTRY

Sorption of Copper by Cellulose

Belford, Preston and co-workers[1,2] have made a study of the sorption of metal ions, particularly the cupric ion, by native cellulose. They suggest that the ions are adsorbed to form a regular two-dimensional lattice on the surfaces of microfibrils by complex formation with hydroxyl groups of the cellulose molecules. Should this be so, copper sorption might give information relating to the surface area of the crystalline fraction in cellulose, and, with such a possibility in view, it was considered worth while to make a further study of the interaction of cellulose with the cupric ion.

Preliminary experiments confirmed that beech α-cellulose[3] and bleached cotton thread do in fact take up copper from copper sulphate solution, but the extent of sorption by the α-cellulose (namely, 0·9 m.mole copper per 100 gm.) was found to be lower than that reported by Belford, Myers and Preston[1] for similar material by a factor of five. In seeking an explanation for this discrepancy, the possibility was considered that acidic groups within the cellulose molecule might be responsible for the uptake of copper, variation in acid content resulting in varying sorption of copper: as a result of further investigation, it now seems reasonably certain that this is the case.

Experiments were carried out on de-waxed, scoured Egyptian cotton, two samples of periodate–chlorite oxycellulose[4], and two samples of nitrogen dioxide oxycellulose[5] prepared from cotton; also studied were 'Tenasco Super 70', 'Viscose Rayon' and 'Fortisan *H*'. Specimens (about 0·5 gm.) were immersed for at least 15 min. in filtered 0·1 *M* copper sulphate solution (100 ml.). The *p*H of the medium was determined before and after immersion of the cellulose samples; in every case immersion was followed by a fall in *p*H of 0·01–0·7 unit (increasing with uptake of copper). Bound copper was removed from the thoroughly washed material in three extractions with 0·1 *N* hydrochloric acid and determined by the standard iodimetric method, using 0·005 *N* sodium thiosulphate. The cellulose specimens were then washed until free from acid and the carboxyl content determined by the alkali back-titration method of Neale and Stringfellow[4,6] using 0·01 *N* hydrochloric acid. Duplicate determinations were made in every case.

Fig. 1 shows that uptake of copper is proportional to the carboxyl content. This would appear convincing evidence that sorption of copper in these experiments is due solely to the presence of carboxylic acid groups in the cellulose molecule: sulphonic acid groups, which might occur in α-cellulose isolated from wood, would presumably act in the same way.

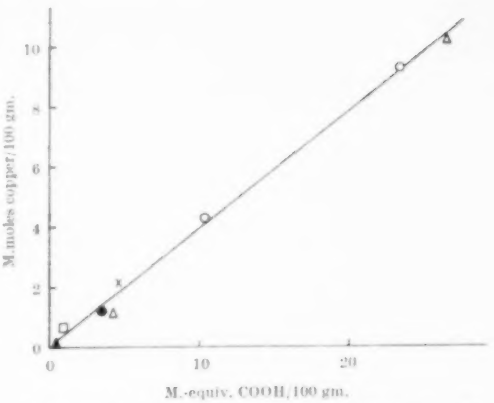


Fig. 1. ▲, Cotton; ○, periodate-chlorite oxycellulose; △, NO_2-oxycellulose; ●, 'Tenasco'; ×, 'viscose'; □, 'Fortisan'

Further evidence that uptake of copper by cellulose is not due to the acidic action of hydroxyl groups was obtained by dissolving 5 gm. of α-methyl-D-glucopyranoside in 100 ml. of 0·1 *M* copper sulphate solution. The *p*H remained unchanged, establishing the absence of any reaction liberating hydrogen ions comparable with that occurring when cellulose takes up copper.

In attempting to interpret the results quantitatively, two apparently conflicting observations must be taken into account: (1) uptake of copper by a beech α-cellulose from 0·1 *M* copper acetate was approximately double that from 0·1 *M* copper sulphate solution[1]; (2) sorption from copper sulphate is governed by a Langmuir isotherm, maximum uptake being virtually attained with 0·1 *M* solution[1]. This would normally be taken to imply that at such concentration all the active sites are occupied.

A possible explanation for the apparent anomaly is forthcoming from a consideration of the equilibria involved, with the simplifying assumption that the system can be treated as one phase. Thus, if K_a is the acid dissociation constant of the carboxyl groups, K_s the dissociation constant of the copper salt ($=[R\mathrm{COO}^-][\mathrm{Cu}^{2+}]/[R\mathrm{COOCu}^+]$) and C the total carboxyl content ($=[R\mathrm{COOH}]+[R\mathrm{COO}^-]+[R\mathrm{COOCu}^+]$), it can be shown that:

$$\frac{C}{[R\mathrm{COOCu}^+]}=\frac{K_s}{[\mathrm{Cu}^{2+}]}+\frac{K_s[\mathrm{H}^+]}{K_a[\mathrm{Cu}^{2+}]}+1 \qquad (1)$$

This would lead to a linear relation between reciprocal copper uptake and reciprocal copper concentration, with a limiting uptake at high copper concentration equal to half the theoretical maximum (that is, equal to half the carboxyl content) if the term $K_s[\mathrm{H}^+]/K_a[\mathrm{Cu}^{2+}]$ were constant and equal to unity. In fact, *p*H measurements on solutions of copper sulphate in the concentration-range 0·005–0·1 *M* have shown that the hydrogen ion activity is approximately proportional to the copper concentration, particularly in the region of higher concentration where more accurate sorption determinations

are possible. If the constants K_a and K_b are given respectively the values of approximately 10^{-2} and 10^{-3} (as would appear not inconsistent with published results[5-7]), equation (1) predicts the observed sorption isotherm and also predicts about a two-fold increase in uptake of copper if the hydrogen ion concentration is decreased by a factor of 10 or more, as is the case in passing from 0·1 *M* copper sulphate to 0·1 *M* copper acetate (namely, sulphate *p*H 4·2, acetate *p*H 5·4). The system is obviously more complicated than depicted here, but it seems reasonable to suppose that the foregoing interpretation of the facts is essentially correct.

To sum up, therefore, the evidence now available makes it appear most probable that sorption of copper from solution by cellulose is due entirely to the action of acidic groups in, or associated with, the cellulose molecules. From this it follows that measurements of sorption of copper cannot be expected to yield any information necessarily related to the physical structure of the cellulose.

I am indebted to Dr. T. P. Nevell, of the Shirley Institute, for providing the specimens of oxycellulose used in this investigation. The work forms part of the programme of fundamental research undertaken by the Council of the British Rayon Research Association.

R. I. C. Michie

Department of Textile Chemistry,
College of Science and Technology,
Manchester 1.

[4] Belford, D. S., Myers, A., and Preston, R. D., *Biochim. Biophys. Acta*, **34**, 47 (1959).
[5] Belford, D. S., and Preston, R. D., *Nature*, **185**, 911 (1960).
[6] Corbett, W. M., and Ewart, J. A. D., *Svensk. Papperstidn.*, **62**, 277 (1959).
[7] Davidson, G. F., and Nevell, T. P., *J. Text. Inst.*, **39**, T102 (1948).
[8] Nevell, T. P., *J. Text. Inst.*, **42**, T91 (1951).
[9] Neale, S. M., and Stringfellow, W. A., *Trans. Farad. Soc.*, **33**, 881 (1937).
[10] *Stability Constants of Metal Ion Complexes*, by Bjerrum, Schwarzenbach and Sillén. Special Publication No. 6, Part 1, p. 3 (Chemical Society, London, 1957).

I am not completely certain that Dr. Michie is discussing quite the same problem as that investigated by my co-workers and me. Although we used the term 'copper-cellulose complex' in some of our papers, we were consciously using the term 'cellulose' as defined by two of us in another connexion[1] as a family of polysaccharides built into microfibrils of a substance which, by virtue of the extraction procedure by which it is obtained and of certain physical properties, is normally called cellulose; we were therefore not discussing those rare products—which we term 'cucellulose'[1]—which yield glucose only on hydrolysis.

In collaboration with Mr. Dennis, I am following up our earlier work on what should be called a 'copper-microfibril' complex. Our results and conclusions will eventually be published *in extenso* elsewhere; at the moment we can say only that the bulk of the uptake of copper is not by the 'pure' cellulose component but by pentosans so firmly bound to the microfibril that they withstand the chemical procedures normally used for the extraction of α-cellulose. It is complexes with these, moreover, which give the sharp electron diffraction diagrams. We are ourselves not certain that copper adsorbed on 'pure' cellulose yields such a diagram; certainly none has been obtained with *Valonia* cellulose in spite of a measurable uptake of copper.

On the point of adsorption in 'pure' cellulose, Dr. Michie may well be correct for the materials and conditions he uses, though his interpretation rests on the straight-line relationship between uptake of copper and the so-called $-COO^-$ content of the cellulose as determined by a method which itself depends on cation adsorption. The difference between the cotton used by him and by us was that, whereas our cotton had been treated with strong alkali in the cold, his had been scoured (that is, boiled in 1 per cent sodium hydroxide). We have reason to believe that the effect of scouring is complex, but we cannot report on this at the moment.

R. D. Preston

Department of Botany,
University,
Leeds.

[1] Myers, A., and Preston, R. D., *Proc. Roy. Soc.*, B, **150**, 447 (1959).

The Borohydride Ion in the Lithium Borohydride Lattice

In a recent communication in *Nature*, Dr. C. J. H. Schutte[1] has suggested that the anomalous band occurring at about 1,250 cm.$^{-1}$ in the paraffin-oil mull spectrum of lithium borohydride at room temperature[2] may be assigned to the doubly degenerate frequency, $\tilde{\nu}_3(E)$, of the tetrahedral BH_4^- ion. This frequency is normally inactive in the infra-red, but it is suggested that under the space-group V_h of crystalline, orthorhombic lithium borohydride, the BH_4^- ions occupy sites of symmetry C_s; the degeneracy is thereby removed so that all the fundamentals are now allowed.

I suggest that confirmation of the above assignment is provided by a previous calculation of some of the vibration frequencies of the tetrahedral hydride ions[3]. The calculation was based on a theoretical discussion of the dynamics of binary hydrides[4], in which it was shown that, with the assumption of a spherical and rigid electron distribution in the molecule, the doubly degenerate frequency, $\tilde{\nu}_3(E)$, of a tetrahedral XH_4 molecule (or ion) could be determined to within 5 per cent by the formula:

$$4\pi^2\tilde{\nu}_3^2 = 9(6)^{1/2}e^2/32\,mr_0^3$$

where e and m are the charge and mass of the proton and r_0 is the equilibrium XH distance. With the value of the B-H distance obtained from proton magnetic resonance measurements on the BH_4^- ion[5], namely 1·25 Å., the above formula gave a calculated frequency of 1,171 cm.$^{-1}$ (= 59 cm.$^{-1}$) for $\tilde{\nu}_3$. This value, therefore, gives good support to the above assignment of Schutte and is also in good agreement with the value of 1,210 cm.$^{-1}$ obtained[6] from measurements of the Raman spectra of solutions of the borohydride ion in liquid ammonia.

D. A. Brown

Department of Chemistry,
University College,
Upper Merrion Street,
Dublin.

[1] Schutte, C. J. H., *Nature*, **189**, 745 (1961).
[2] Price, W. C., *J. Chem. Phys.*, **17**, 1044 (1949).
[3] Brown, D. A., *J. Chem. Phys.*, **29**, 451 (1958).
[4] Longuet-Higgins, H. C., and Brown, D. A., *J. Inorg. and Nuclear Chem.*, **1**, 60 (1955).
[5] Ford, P. T., and Richards, R. E., *Discuss. Farad. Soc.*, **19**, 230 (1955).
[6] Taylor, R. C., Schultz, D. R., and Emery, A. R., *J. Amer. Chem. Soc.*, **80**, 27 (1958).

Although the comments of Dr. Brown on my communication are very encouraging for further theoretical investigations, it should be pointed out that the equation used by Brown to calculate the doubly degenerate $\tilde{\nu}_2(E)$ vibration of the BH_4^- ion was derived for a tetrahedral ion or molecule which has a spherical and rigid electron distribution. This assumption is certainly not valid in the case of the BH_4^- ion in the $LiBH_4$ lattice. In this lattice the tetrahedral ion is considerably deformed, having the site symmetry C_s. In addition, it must be pointed out that the crystalline field in which any ion is embedded has a profound influence on the frequencies of vibrational modes (see, for example, refs. 1 and 2). The frequency of ν_2, calculated according to the formula derived by Brown, is that of the free tetrahedral BH_4^- ion and can only be compared, for example, with the Raman frequencies of BH_4^- in liquid ammonia.

C. J. H. Schutte

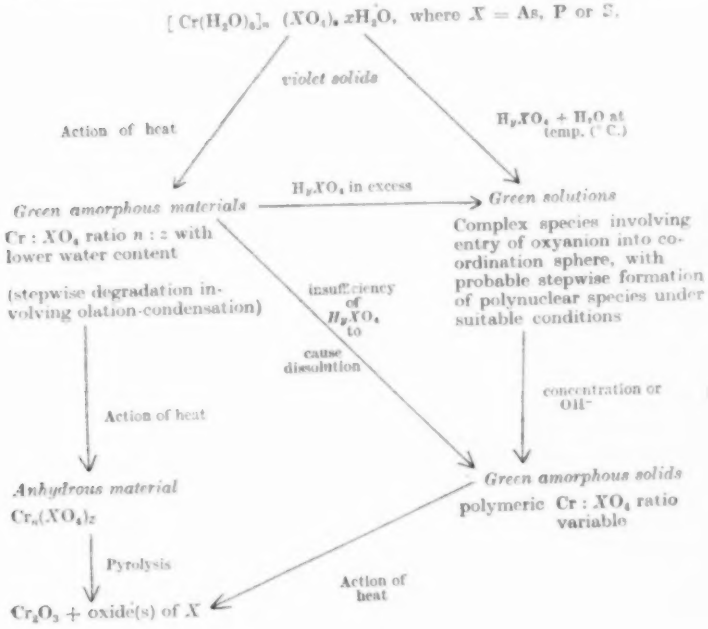
Chemical Physics Group,
National Chemical and Physical Research Laboratories,
Council for Scientific and Industrial Research,
Pretoria.

[1] Strashelm, A., and Buijs, K., *J. Chem. Phys.*, **34**, 691 (1961).
[2] Ketelaar, J. A. A., Schutte, C. J. H., and Schram, B. L., *Spectrochim. Acta*, **13**, 336 (1959).

Chromium(III) – Oxyanion Systems

Certain hexaquochromium(III) oxyanion compounds (in particular, the phosphate, arsenate and sulphate) have shown marked similarities in their behaviour on thermal degradation and in solutions with their corresponding oxyacids. This behaviour can best be explained on the basis of olation-condensation reactions which are believed to occur both in the solid state and in solution.

The behaviour may be represented schematically:


[Cr(H2O)6]n (XO4)n xH2O, where X = As, P or S.
violet solids
Action of heat
HyXO4 + H2O at temp. (° C.)
HyXO4 in excess
Green amorphous materials
Cr : XO4 ratio n : z with lower water content
(stepwise degradation involving olation-condensation)
Green solutions
Complex species involving entry of oxyanion into co-ordination sphere, with probable stepwise formation of polynuclear species under suitable conditions
insufficiency of HyXO4 to cause dissolution
concentration or OH-
Action of heat
Anhydrous material
Crn(XO4)z
Green amorphous solids
polymeric Cr : XO4 ratio variable
Pyrolysis
Action of heat
Cr2O3 + oxide(s) of X

Work on the solution and solid phases of the systems: Cr_2O_3–P_2O_5–H_2O at 0°, 40°[1], and 70°[2], Cr_2O_3–As_2O_5–H_2O at 25°[3] has already been reported. The system Cr_2O_3–SO_3–H_2O is being studied at 25° and 70°.

Thermogravimetric studies of hexaquochromium(III) phosphate, arsenate and sulphate indicate that the dehydration process is complex. Inflexions in curves of the loss in weight against temperature are interpreted as stages in a process of olation-condensation occurring in the solid phase, which is initiated by the entry of the oxyanion into the chromium(III) co-ordination sphere. Such a process is expected to result in the formation of cross-linked polymers incorporating groupings of the type:

Where A = HXO_4^{a-}, B = OH^- or HXO_4^{a-} or no linkage, and C = HXO_4^{a-}, $H_2XO^{(a-1)-}$, or H_2O.

This type of structure accounts for the ion-exchange properties encountered in these systems[2,3]. X-ray studies have shown that the products of dehydration of these hexaquochromium(III) salts are amorphous and possess no long-range order. This might be accounted for by a random arrangement of the bridging groups. However, recrystallization occurs in these materials prior to complete dehydration to the phase $Cr_n(XO_4)_z$.

The kinetics of thermal decomposition have been studied by the method developed by Freeman and Carroll[4]. The results are presented in Tables 1–3, together with supporting evidence obtained from preliminary differential thermal analysis.

Infra-red studies of the products of progressive dehydration show that the characteristic absorption bands associated with water in the complex are initially extremely broad due to the effect of hydrogen bonding. In the course of the dehydration this band (3,750–2,100 cm.$^{-1}$) becomes modified in length and intensity, shortening occurring in the 3,750–3,100 cm.$^{-1}$ region. Finally the band disappears on complete dehydration (together with that due to the bending vibrations ($\sim$1,600 cm.$^{-1}$)). The characteristic bands of the oxyanion undergo broadening and splitting in the course of dehydration—implying a lowering of T_d symmetry, which might be expected if the formation of HXO_4-groups were involved. Magnetic studies on the arsenate have shown that the compound obeys the Curie–Weiss law down to liquid-nitrogen temperatures and has a very small value of the Weiss constant θ. Progressive dehydration of this material

Table 1. HEXAQUOCHROMIUM(III) SULPHATE—$[Cr(H_2O)_6]_2(SO_4)_3.16H_2O$

Temp. (° C.)	Loss	Stage (hydration)	Colour	Activation energy (E) kcal.	Reaction order (n)	Differential thermal analysis observations
25		16-H_2O	violet	—	—	
60	1-H_2O (lattice water)		violet	5	1	
100		15-H_2O				
120	5-H_2O quickly		deep green	30	1	Two broad and consecutive endothermic effects
170		10-H_2O (inflexion)				
300	5-H_2O quickly		green	$\simeq$ 50	2	
390		5-H_2O				
450	~ 3·5-H_2O		lime green	6·5	1·2	Small endothermic effect
530	1·5-H_2O	1·5-H_2O	yellow green			
635	0·5-H_2O	1-H_2O	light brown	very small	—	Exothermic effect
780	1-H_2O lost	Anhydrous	deep brown	very small		
	loss of SO_3	Cr_2O_3 formed	green deep green	11·5	0·6	Endothermic effect

Table 2. HEXAQUOCHROMIUM(III) ARSENATE—$[Cr(H_2O)_6]AsO_4$

Temp. (° C.)	Loss	Stage (hydration)	Colour	Activation energy (E) kcal.	Reaction order (n)		Differential thermal analysis observations
		(slow decomposition) 6-H_2O	grey-violet	—	—		—
25						50°	
60	2-H_2O lost	4-H_2O	light green	5	0·6		Broad endothermic effect
110	2-H_2O lost	2-H_2O	green	17	2		
280	1-H_2O lost	1-H_2O	grey	—	—	260°	
400	½-H_2O lost	½-H_2O	light brown	22	1	450°	
	very gradual water loss	anhydrous	brown	—		600°	Exothermic effect
900							
1,200	loss of As_2O_5		deep green	29	2	~ 1,200°	Endothermic effect
1,400		Cr_2O_3 formed					

Table 3. HEXAQUOCHROMIUM(III) PHOSPHATE $[Cr(H_2O)_6].PO_4$

Temp. (° C.)	Loss	Stage (hydration)	Colour	Activation energy (E) kcal.	Reaction order (n)	Differential thermal analysis observations*
25		6-H_2O	violet	—	—	
100	2-H_2O lost		violet	10·5	1	
250		4-H_2O (inflexion)	bright green			Endothermic effect observed between 150–300°
300	2-H_2O lost		light brown	7	1·8	
400	1-H_2O lost	2-H_2O	dark brown	5·5	1	
650	½-H_2O lost slowly	1-H_2O	black	very small	—	
1,000		~ ½-H_2O	black			
1,300		~ Anhydrous	light green	—	—	Exothermic effect at around 1,100° C.
1,400		Anhydrous $CrPO_4$ stable				
> 1,400			light green	—	—	

* Due to Sullivan and McMurdie (ref. 6)

does not show any departure from the linear law, although a progressive increase in θ is observed, a value of $\sim 30°$ K. being obtained for $CrAsO_4.\frac{1}{2}H_2O$. Such behaviour would seem to indicate the absence of —O—links in the polymeric compounds[5].

G. M. LUKASZEWSKI
J. P. REDFERN

Battersea College of Technology,
London, S.W.11.

[1] Jameson, R. F., and Salmon, J. E., *J. Chem. Soc.*, 360 (1955).
[2] Redfern, J. P., and Salmon, J. E., *J. Chem. Soc.*, 291 (1961).
[3] Lukaszewski, G. M., Redfern, J. P., and Salmon, J. E., *J. Chem. Soc.*, 39 (1961).
[4] Freeman, E. S., and Carroll, B., *J. Phys. Chem.*, **62**, 394 (1958).
[5] Earnshaw, A., and Lewis, J., *Nature*, **181**, 1262 (1958).
[6] Sullivan, B. M., and McMurdie, H. F., *J. Res. Nat. Bur. Stand.*, **48**, 159 (1952).

Assurance of Thermostatic Control during Electrophoretic Experiments

PRECISE thermostatic control is of paramount importance if absolute electrophoretic mobilities are to be measured. Moreover, recently proposed supporting media in the form of gels (starch gel and cyanogum gel) introduce an additional need for constant temperature since the diameters of the gel pores (a factor largely determining migration in those media) depends on thermal agitation of the pore-forming bridges[1].

Generally, electrophoresis in a supporting medium is conducted without positive control of temperature. At best, the medium is placed in a container maintained at constant temperature (for example, an ice chest) and the temperature gradient existing between the room and the medium is kept within reasonable limits by using small field strengths and low ionicities. Another method is that of using a cooling fluid circulating in rather close contact with the electrophoretic medium. Yet in all those methods it is the temperature of the cooling medium that is directly controlled and not that of the electrophoretic medium itself.

This could, nevertheless, easily be achieved if use were made of the following property: since the medium used for electrophoresis has nearly always electrolytic conductivity, it possesses a rather large (negative) temperature coefficient. Thus the resistance of the medium could be used as a temperature-sensing element. Resistance variations can easily be converted into voltage variations if the electric field is established from a power supply regulating for constant intensity. Indeed, if the temperature of the electrophoretic medium rises, its resistance decreases, and to maintain a constant current intensity, the voltage at the electrodes will automatically be reduced. This decrease in voltage can be made to

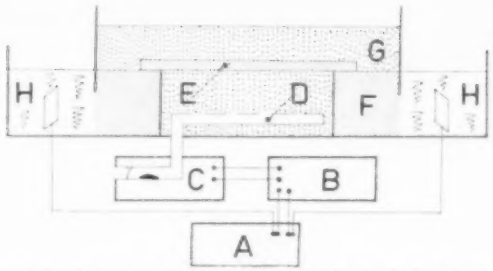


Fig. 1. Diagram of the apparatus for conducting high-voltage agar-gel electrophoresis at constant temperature. *A*, Electric power supply regulating for constant intensity; *B*, amplifier that closes a relay if the voltage at *A* decreases; *C*, air pump switched on by relay in *B*; *D*, tube provided with small holes for blowing air in *G*; *E*, electrophoresis plate; *F*, agar gel; *G*, petroleum ether; *H*, electrode vessels

close a relay, switching on some cooling device. The temperature will go down again and the voltage will rise to its initial value. At that moment active cooling will be cut out. In fact, electrophoresis is then conducted at (nearly) constant intensity and voltage.

Very effective cooling, giving the additional advantage of sealing the electrophoretic medium against evaporation, is obtained by bathing that medium in a neutral, volatile fluid: if its evaporation is activated, the heat generated in the electrolyte is absorbed. Evaporation of the volatile fluid is easily controlled by blowing finely dispersed air through it; this makes at the same time for effective stirring.

These principles[2] have been applied to a technique of agar-gel electrophoresis described some time ago[3]. The experimental apparatus is illustrated in Fig. 1. The electrophoresis plate is bathed in petroleum ether of low boiling point (25–50° C.). A small air pump blows air through a tube provided at its distal end with small holes. If the temperature of the electrophoresis plate tends to rise, the pump starts blowing air until the temperature in the plate has reverted to its initial value. In an actual experiment effected at a field-strength of 30 V./cm. (agar 1 per cent in barbital buffer of *p*H 8·4 and ionicity 0·05) and conducted at 12° C., the temperature variations in the plate were found to be less than 1° C., with the pump acting in short cycles at a frequency of 8/min. With this method any temperature between +4° C. and 25° C. can be set by activating the evaporation of the petroleum ether prior to the experiment, until the fluid is at the desired temperature. The plate is then left for a few minutes to reach temperature equilibrium. The electric field is then applied and the temperature in the plate will automatically be maintained at a constant value.

Separations, already of outstanding quality when agar gel is used, are even better if the separation is effected at low temperature (+4° C.), since diffusion is then strongly checked while the decrease in mobility can be compensated for by increasing the electric field strength. Application of the principles here exposed to other types of electrophoresis, for example to the column type, could be fruitful.

R. J. Wieme*

Laboratory of the Medical Clinic,
University of Ghent,
Pasteurdreef 2, Ghent, Belgium.

* Associate of the National Foundation for Scientific Research in Belgium.

[1] Poulik, M. D., and Smithies, O., *Biochem. J.*, **68**, 636 (1958).
[2] Patents applied for.
[3] Wieme, R. J., *Clin. Chim. Acta*, **4**, 317 (1959).

BIOCHEMISTRY

Quinine Oxidase in Liver and Blood Plasma of Rabbits poisoned with Carbon Tetrachloride

Rabbit liver has been shown to be a rich source of quinine oxidase[1,2]. The enzyme was also demonstrated in other organs of the rabbit but in much smaller amount (spleen, lungs); none was found in the pancreas, heart, kidney and skeletal muscles[2]. In normal human blood, quinine oxidase is present in negligible amounts. However, in cases of parenchymatous lesions of the liver, increased amounts could be detected in the blood. Therefore, the determination of this enzyme has been recommended by Baier[3] and by Roman and Dulmanis[4] as a test for liver damage.

Since carbon tetrachloride is regarded as a strong hepatotoxic agent, I decided to investigate its effect on quinine oxidase of the liver and blood plasma.

Quinine oxidase was determined using a method previously worked out and based on the reduction of the dye triphenyltetrazolium chloride in evacuated Thunberg tubes, the substrate being *N'*-methylnicotinamide[5]. The formazan produced after the incubation of the reaction mixture for 15 min. at 37° C. was extracted with petroleum ether and the colour measured in a Beckman quartz spectrophotometer at 480 mμ. *N'*-methylnicotinamide (7×10^{-3} *M*) was used instead of quinine hydrochloride since Knox[1] and also Lang and Keuer[4] demonstrated that this compound is the natural substrate for the enzyme. Blood plasma quinine oxidase was also measured by the increase in the absorption at 366 mμ of the carbostiryl oxidation product of quinine, using Baier's method[3,6]. Heparinized plasma was used throughout.

The enzyme could not be detected in the blood plasma of normal rabbits by the formazan reagent or by Baier's methods. It was, however, soon verified that a few hours after the injection of carbon tetrachloride the enzyme decreases in liver and appears in the blood. Table 1 summarizes this result.

Table 1. Effect of Injected Carbon Tetrachloride on the Liver and Blood Plasma of the Rabbit

Conditions	No. of rabbits	Averages and standard deviations: Liver (μgm. formazan/gm. wet weight)	Blood plasma (Baier units)
Normal	10	21·5 ± 3·4	0
Carbon tetrachloride	10	9·2 ± 5·7	138 ± 42

Rabbits were dosed with carbon tetrachloride, 0·05 ml./100 gm. body-weight intraperitoneally and killed after 12 hr. Baier unit = increase of 0·001 in optical density at 366 mμ.

Some experiments were also performed to find the time of appearance and the level of this enzyme in blood plasma during the course of poisoning. A group of four rabbits weighing 600–920 gm. were injected intraperitoneally with 0·05 ml. of carbon tetrachloride/100 gm. body-weight and the blood withdrawn by heart puncture and analysed 3, 5 and 10 hr. after the injection. Four other animals were bled after 15 and 20 hr. Fig. 1 shows the average increase up to 20 hr.

Blood plasma of poisoned rabbits was saturated with ammonium sulphate solution (v/v) to find which fraction carries the enzyme. The protein precipitate was separated, dissolved in distilled water made slightly alkaline (*p*H 7·2) and dialysed in 'Cellophane' bags against distilled water at 4° C. The enzyme

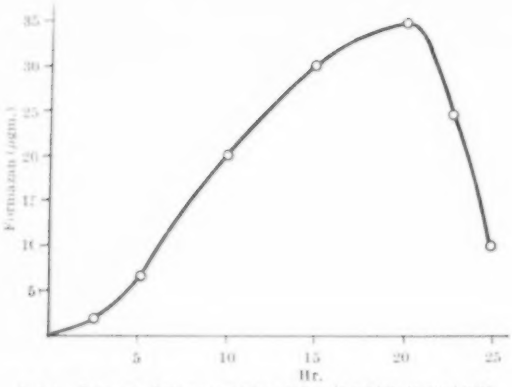


Fig. 1. Increase of plasma quinine oxidase in rabbits treated with carbon tetrachloride. Values expressed in μgm. formazan/1 ml. of plasma

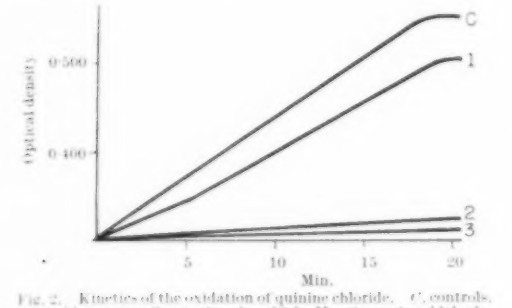


Fig. 2. Kinetics of the oxidation of quinine chloride. *C*, controls. 1, *p*-chloromercuribenzoate, 1×10^{-5} *M*. 2, crotonaldehyde, 7×10^{-3} *M*. 3, 0·1 ml. menadione, 0·4 *M*

activity was found only in the globulin fraction. A typical experiment is reproduced in Table 2.

Neither normal rats nor rats treated with carbon tetrachloride showed any quinine oxidase activity in the blood plasma. This suggests that in the rat the enzyme is not easily removed from the liver cells as in the rabbit. It appears, therefore, that this enzyme behaves differently from xanthine oxidase, which increases rapidly in the liver and blood of rats treated with carbon tetrachloride as previously reported by us[7]. It must be remembered that the liver of the rabbit is poor in xanthine oxidase and the blood is devoid of it. The localization in the liver cells of the rat and the association of this enzyme with lipids[8] may be responsible for the differences observed between their behaviour in carbon tetrachloride poisoning.

Liver quinine oxidase was inhibited by crotonaldehyde, *o*-iodobenzoic acid and 2-methyl-1,4-naphthoquinone(menadione), slightly inhibited by *p*-chloromercuribenzoate and not affected by 2-amino-4-hydroxy-6-pteridine aldehyde (Table 3). The kinetics of the oxidation of quinine chloride were followed in plasma by the increase in optical density at 366 mμ in the presence of *p*-chloromercuribenzoate, crotonaldehyde and menadione.

Table 2. Quinine Oxidase in Blood Fractions

	Activity*
Control plasma	150
Globulin fraction (corrected to the initial volume)	147
Albumin fraction	0

* Activity in μgm. formazan/100 ml. blood plasma.

Table 3. Effect of Inhibitors on the Quinine Oxidase of Cell-free Liver Homogenate

Inhibitors	Formazan produced (μgm.)	Inhibition (per cent)
Controls	30·8	—
6-Pteridyl aldehyde (30 μgm.)	30·0	0·9
p-Chloromercuribenzoate, 1×10^{-5} *M*	26·0	16
o-Iodosobenzoic acid, 2×10^{-3} *M*	13·0	58
Crotonaldehyde, 1×10^{-2} *M*	12·1	61
Menadione, 2×10^{-2} *M*	0	100

Liver homogenate 1:1 in phosphate buffer *p*H 7·4. Centrifuged 30 min. at 3,500 r.p.m. Total volume of the reaction mixture in the Thunberg tube, 2 ml. (ref. 5).

These results indicate that quinine oxidase is partly dependent to SH— groups for full activity. Work is now in progress to investigate the effect of other inhibitors.

Gilberto G. Villela

Biochemical Laboratory,
Instituto Oswaldo Cruz,
Rio de Janeiro,
Brazil.

[1] Knox, W. E., *J. Biol. Chem.*, **163**, 699 (1946). Lang, K., and Keuer, H., *Biochem. Z.*, **329**, 277 (1957).
[2] Kelsey, F. E., and Oldham, F. K., *J. Pharm. Exp. Ther.*, **79**, 77 (1943).
[3] Baier, H., *Klin. Wochenschr.*, **36**, 569 (1958).
[4] Roman, W., and Dulmanis, A., *Lancet*, ii, 90 (1959).
[5] Villela, G. G., *Acad. Bras. Cienc.* (in the press).
[6] Baier, H., and Lang, K., *Biochem. Z.*, **329**, 384 (1957).
[7] Villela, G. G., and Mitidieri, E., *Nature*, **175**, 208 (1955). Affonso, O. R., Mitidieri, E., Ribeiro, L. P., and Villela, G. G., *Proc. Soc. Exp. Biol. Med.*, **90**, 527 (1955)
[8] Mitidieri, E., Affonso, O. R., Ribeiro, L. P., and Villela, G. G., *Biochim. Biophys. Acta*, **17**, 587 (1955).

Isolation of the Toxic Principle in *Acacia georginae*

Serious losses in livestock, apparently due to poisoning by natural fodder, have occurred in the Georgina River watershed since early settlement. These occur over an area of approximately 14,000 square miles of north-western Queensland and over an equally large area of the adjoining Northern Territory. *Acacia georginae* is widely distributed throughout the affected areas, and its pods, seeds and leaves have proved toxic to sheep and cattle[1,2].

The isolation and identification of the toxic principle in the seeds of *A. georginae* is now reported. Previous investigations[3] showed seeds to contain a complex mixture of carbohydrates, amino-acids and pinitol, but failed to characterize the toxic factor. This has now been identified as the fluoracetate ion.

Seeds were extracted with ethanol and standard procedures used to separate into acidic, basic and neutral fractions. The acid extract was purified by repetitive re-extraction from ether with sodium bicarbonate and finally by fractional distillation of the volatile acids so obtained. The toxic factor was identified as the fluoracetate ion by conversion to the butyl ester and the use of gas chromatography aided by an authentic specimen of butyl fluoracetate. Infra-red absorption spectra confirmed the identification.

Toxicity tests on laboratory animals and on sheep with potassium fluoracetate in quantities comparable with those found in the seeds of *A. georginae* produced identical symptoms.

The occurrence of fluoracetate has been reported in *Dichapetalum cymosum* (*Chailletia cymosa*) in South

Africa[4], this plant being responsible for serious stock losses.

P. B. Oelrichs
T. McEwan

Animal Research Institute,
Department of Agriculture and Stock,
Brisbane.

[1] Bell, A. T., Newton, L. G., Everist, S. L., and Legg, J., *Austral. Vet. J.*, **31**, 249 (1955).
[2] Barnes, J. E., *Austral. Vet. J.*, **34**, 281 (1958).
[3] Winka, D. J., M.Sc. thesis, University of Queensland.
[4] Rimington, C., and Steyn, D. G., *Onderstepoort Vet. Sci. and Anim. Ind.*, **5**, 81 (1935).

Origin of β-Aminoisobutyric Acid in Iris

Asen *et al.*[1] have recently added β-amino*iso*butyric acid (BAIB) to the growing list of amino-acids found in higher plants by isolating this compound from the roots of *Iris tingitana* var. Wedgewood. Fink *et al.*[2,3] have shown that BAIB can arise metabolically from thymine via dihydrothymine and β-ureido*iso*butyric acid in the rat. This discovery, taken in conjunction with our recent observation[4] that the higher plant *Brassica napus* (rape) forms radioactive dihydrothymine, β-ureido*iso*butyric acid and carbon dioxide from 2-^{14}C-thymine, strongly suggested to us that, in iris, thymine might well be the source of BAIB. This possibility was tested by supplying totally tritiated thymine to tissue sections of *Iris tingitana* var. Wedgewood.

Small disks (5 mm. diam., 1 mm. thick) were cut from the interior of a freshly dug iris root which had just finished blossoming. The disks (0·3 gm.) were incubated in air, at 28° C., in 1·0 ml. 0·03 *M* phosphate buffer, *p*H 5·0, which contained 5×10^{-3} μmoles of ^{3}H-thymine ($2{\cdot}4 \times 10^7$ c.p.m. counted as a weightless sample with a windowless Geiger counter). Following incubation for periods of 2, 4, 6 and 20 hr. the incubation mixtures were homogenized in a Potter–Elvehjem homogenizer with sufficient 75 per cent ethanol to yield a final volume of 5·0 ml. and filtered. The filtrates were taken to dryness in a stream of nitrogen, freed of lipoidal materials by extraction with petroleum ether and dissolved in a small quantity of water. The extracts were chromatographed on Whatman No. 1 filter paper employing solvent No. 5 of Fink *et al.*[3]. The radioactive regions on the developed chromatograms were located with a recording windowless scanning device (Forro radioscanner). In all cases the scanning records revealed the presence of a radioactive area corresponding precisely with authentic BAIB, the presence of which was revealed with ninhydrin. To establish further the identity of the putative BAIB, the radioactive product in question was eluted and portions thereof re-chromatographed on Whatman No. 1 paper, with three additional solvents: solvent No. 1 and No. 2 of Fink *et al.*[3] and *n*-butanol/acetic acid/water, 6 : 1 : 2 (v/v/v), of Asen *et al.*[1]. Correspondence between the radioactive area and the position of authentic unlabelled BAIB was satisfactory.

Still other portions of the eluate were converted to the N-dinitrophenyl derivative by treatment with fluoro-2,4-dinitrobenzene[5]. Since the quantities of the suspected BAIB were too small to yield sufficient dinitrophenyl derivative to be visibly yellow when applied to the paper chromatogram a small quantity of authentic unlabelled BAIB (100 μgm.) was added to the dinitrophenylation reaction mixture. The product was isolated and chromatographed on paper which had been previously treated with phthalate buffer[6]. Development was carried out with water-saturated butanol. On scanning the chromatogram for radioactivity, the dinitrophenyl derivative of the unknown was found to coincide with the yellow dinitrophenyl-BAIB. BAIB was detected in all the incubation experiments.

It is, therefore, reasonable to assume that the breakdown of thymine can account for the presence of BAIB which Asen *et al.* discovered in iris. ^{3}H-thymidine also yielded BAIB under similar conditions although it was a much poorer source than thymine. The thymidine was contaminated with a trace of thymine too slight to account for the BAIB formed. Presumably the free base is liberated from thymidine by a phosphorylase or hydrolase.

It is quite likely that the route to BAIB formation is via the Fink pathway[3], that is, through dihydrothymine and β-ureido*iso*butyric acid, since these two substances were found to be radioactive in the extracts obtained in the above experiments with thymine. These compounds were identified as described elsewhere[4] using slight modifications of the procedures of Fink *et al.*[3]. Still further evidence for the participation of this pathway comes from the observation that when the radioactive thymine was diluted 5,000-fold with unlabelled dihydrothymine (25 μmoles), no radioactive BAIB could be detected after 20 hr. incubation.

This work was supported by the North Central Regional Research Project *NCM-23*.

W. R. Evans
Chi Shiun Tsai
Bernard Axelrod

Biochemistry Department,
Purdue University,
Lafayette, Indiana.

[1] Asen, S., Thompson, J. F., Morris, C. J., and Irrevere, F., *J. Biol. Chem.*, **234**, 343 (1959).
[2] Fink, K., Henderson, R. B., and Fink, R. N., *J. Biol. Chem.*, **197**, 441 (1952).
[3] Fink, K., Cline, R. E., Henderson, R. B., and Fink, R. M., *J. Biol. Chem.*, **221**, 425 (1956).
[4] Evans, W. R., and Axelrod, B., *Plant Physiol.* (in the press).
[5] Levy, A. L., *Nature*, **176**, 126 (1954).
[6] Porter, R. R., in *Methods in Enzymology*, edit. by Colowick, S. P., and Kaplan, N. O., **4**, 228 (Academic Press, New York, 1955).

A Supplement to the Kober Reaction for Urinary Œstrogens

Ittrich[1] has shown that the pink colour given by natural œstrogens in the Kober reaction with sulphuric acid can be extracted by chloroform when the acid is diluted to 20–30 per cent. The colour fades, but can be stabilized somewhat by using a 2 per cent solution of *p*-nitrophenol for extraction. Other workers[2] have preferred tetrachloroethane to chloroform.

The Kober colour could be extracted more readily if dilution were performed with aqueous trichloroacetic acid instead of water, and was then more resistant to fading. Under these conditions, *p*-nitrophenol was not needed. Because of the favourable partition ratio, the colour can be concentrated in a small volume of organic phase, and much of the 'background colour' remains in the diluted sulphuric acid. The extracted Kober colour absorbs maximally at a longer wave-length than in sulphuric acid.

Colorimetric measurement of œstrogen in male and post-menopausal urine is frequently near the limits of sensitivity of the method. Concentration of feeble colours by extraction into chloroform–trichloroacetic acid should enable low levels of œstrogen to be measured spectrophotometrically with greater confidence, and the spectral shift is a check on the authenticity of the Kober colour. It is suggested that the following type of procedure may be valuable as a supplement to the conventional analytical procedures for œstrogen utilizing the Kober reaction[1-4]. For œstrone or its methyl ether: dilute a 3-ml. aliquot of the Kober colour (after reading) with 1·8 ml. of 2 *N* trichloroacetic acid in a pointed centrifuge tube, stopper, mix, cool under the tap, add 1·2 ml. of chloroform, shake for 20 sec., centrifuge briefly, suck off top layer and discard, read the bottom layer in a 1 ml. cuvette at 502, 532, 562 mμ (508, 538, 568 mμ for the ether) in a spectrophotometer. This gives an Allen corrected value about three times as great as that derived from measurements on the original Kober colour. The chloroform extract fades about 3 per cent in ½ hr. Tetrachloroethane is objectionably toxic, though an excellent solvent.

I thank Dr. P. B. Hudson, Francis Delafield Hospital, New York, for the opportunity to do this work while a guest in his laboratories.

L. Bradshaw

Department of Experimental Pathology
and Cancer Research,
The Medical School,
Thoresby Place,
Leeds 2.

[1] Ittrich, G., *Z. physiol. Chem.*, **312**, 1 (1958).
[2] Adlercreutz, H., Diczfalusy, E., and Engstrom, L., *Endocrinol.*, **66**, 80 (1960), quoting a personal communication from Salokangas, R. A. A., and Bulbrook, R. D.
[3] Brown, J. B., *Biochem. J.*, **60**, 185 (1955).
[4] Bauld, W. S., *Biochem. J.*, **63**, 488 (1956).

Controlled Use of Adsorbents in Enzyme Purification

Published methods for the purification of many enzymes specify the use of $C\gamma$-aluminium hydroxide gel[1] or calcium phosphate gel[2] as adsorbents, and Colowick[3] has reviewed the use of these methods.

The adsorbents may be used (*a*) preferentially to adsorb contaminants from solution or (*b*) preferentially to adsorb the enzyme from solution. These may be regarded as the two gross extremes of (*c*) a graded fractional adsorption, and Ochoa[4] has used all three procedures for the purification of the 'malic' enzyme from different sources.

However, the use of fractional procedures is reported only rarely in the literature, and most authors seem to make use of a technique which superficially resembles (*b*). This procedure is carried out in such a way as to afford little chance for investigating, and thus utilizing, the possibly fine resolving power of the adsorbents. The gel suspension is usually added in one or two large batches to adsorb all the enzyme and, after sedimentation, the gel is washed and eluted.

In this communication the behaviour is reported of two different enzyme preparations on different gels, and evidence is presented of differential adsorption of protein during the procedure. The results emphasize the importance of fractional adsorption in enzyme purification with gels, and indicate that this technique can lead to greater purification than is possible using the popular technique above.

The method requires titration of the enzyme remaining in solution after addition of small batches of adsorbent, and a rapid method for the assay of enzymatic activity is desirable for convenient working.

(1) *Preparation of glucose-6-phosphate dehydrogenase.* This enzyme can be conveniently prepared from dried baker's yeast, but is usually contaminated with hexokinase. In a method used in this laboratory (unpublished), the hexokinase activity is destroyed by mild-heat treatment of a yeast autolysate and nucleic acids are precipitated by protamine sulphate. Some impurities are removed by iso-electric precipitation and the crude enzyme is fractionated with ammonium sulphate. Treatment with $C\gamma$ alumina results in further purification.

Table 1 shows the results obtained in this step by the popular procedure and the fractional method.

Table 1. Fractionation of Glucose-6-Phosphate Dehydrogenase with Alumina Gel

Method 1:
Enzyme adsorbed from 0·05 *M* acetate buffer *p*H 5·5 with 2·5 ml. of $C\gamma$ alumina (11 mgm. solids/ml.). Gel precipitate collected by centrifugation, washed with 0·05 *M* acetate *p*H 5·5, eluted three times with 0·1 *M* phosphate buffer *p*H 7·4.

Volume of gel added (ml.)	Total units* of enzyme in solution	Total protein† (mgm.)	Specific activity (units/mgm. protein)
0	260	20	13
2·5	31	—	—
Alumina eluate	230	9·7	24

Method 2:
Enzyme solution in 0·05 *M* acetate buffer *p*H 5·5, 29·0 ml. of $C\gamma$ alumina suspension added. Gel precipitate discarded, 30 ml. of $C\gamma$ alumina added to enzyme solution. Gel collected by centrifugation washed and eluted as above.

Volume of gel added (ml.)	Total units* of enzyme in solution	Total protein† (mgm.)	Specific activity (units/mgm. protein)
0	2,430	200	12
29	2,300	—	—
30	36	—	—
Alumina eluate	2,010	34	59

* Determined by the rate of reduction of triphosphopyridine nucleotide ($0·2 \times 10^{-3}$ *M*) in the presence of *tris* (hydroxymethyl)-aminomethane buffer (0·03 *M*, *p*H 7·4), magnesium chloride (3×10^{-3} *M*) and glucose-6-phosphate (10^{-3} *M*) in a Beckman *DU* spectrophotometer at 30° C. The unit of dehydrogenase activity is defined as an optical density change of 0·100 per min. at 340 mμ and 30° C.
† Determined by the biuret method (ref. 5).

These results indicate that the fractional procedure gives a superior purification factor in this case. In method 1, the specific activity of the enzyme increases by a factor of about 1·9, while in the second method the increase in the factor is about 5.

(2) *Preparation of uridinediphosphoglucose (UDPG) dehydrogenase.* This enzyme is prepared from fresh calf-liver by a modification of a method previously applied to acetone powders of liver[6].

Fresh calf-liver is treated in a Waring blender with 0·15 *M* potassium chloride and centrifuged. The supernatant solution is fractionated with ammonium sulphate, heat treated and fractionated again with ammonium sulphate. Calcium phosphate gel is then used in the fractional adsorption procedure.

In this step, the differential adsorption occurs of some other system (of unknown type) which interferes strongly with the assay method for UDPG dehydrogenase. This is demonstrated by the data in Table 2. As more gel suspension is added, the apparent activity of the dehydrogenase in solution rises to a peak value, and then begins to fall. At the peak value

Table 2. Fractional Adsorption of UDPG-Dehydrogenase with Calcium Phosphate Gel

Adsorption of enzyme from solution in 0·01 *M* phosphate *p*H 6·8	
Total volume of gel added (ml.)	Total units* of enzyme in solution
0	12·4
9·0	36·3
18·0	49·5
30·0†	60·2
3·0	50·5
6·0	46·5
21·0	31·5
51·0	0

* Measured by the rate of reduction of diphosphopyridine nucleotide (7×10^{-4} *M*) in presence of glycine buffer (0·15 *M*, *p*H 8·7) and UDPG ($1·5 \times 10^{-4}$ *M*). Micro-cells with total volumes of 0·7 ml. were used in a Beckman *DU* spectrophotometer at 30° C. The unit of enzyme activity is defined as a change in optical density at 340 mμ of 0·100 per min. at 30° C.

† At this point all the added gel was discarded; 23 per cent of the total protein had disappeared from solution.

in a typical experiment, 23 per cent of the total protein had been adsorbed to the gel.

It can be seen that the fractional procedure brings about removal of an interfering system as previously mentioned, together with a substantial amount of protein. During the latter part of the step, the enzyme is adsorbed to the gel. The gel is washed with 0·01 *M* phosphate *p*H 6·8 and the enzyme eluted with 0·1 *M* phosphate buffer *p*H 7·4. Quantitative recovery of the enzymes (peak values) have been obtained in these experiments.

The results indicate that in procedures for the purification of other enzymes or proteins which involve the use of adsorption-elution techniques, the fractional methods described here may be of considerable value. Such procedures are relatively easy to apply provided that rapid assay methods are available.

I. T. Oliver

Department of Biochemistry,
University of Western Australia,
Nedlands.

[1] Willstätter, R., and Kraut, H., *Ber.*, **56**, 1117 (1923).
[2] Keilin, D., and Hartree, E. F., *Proc. Roy. Soc.*, B, **124**, 397 (1938).
[3] Colowick, S. P., *Methods in Enzymology*, **1**, 90 (Academic Press, Inc., New York, 1955).
[4] Ochoa, S., Mehler, A. H., and Kornberg, A., *J. Biol. Chem.*, **174**, 979 (1948). Verga Salles, J. B., and Ochoa, S., *ibid.*, **187**, 849 (1950). Harary, I., Korey, S. R., and Ochoa, S., *ibid.*, **203**, 595 (1953).
[5] King, E. J., and Wootton, I. D. P., *Microanalysis in Medical Biochemistry*, third ed. (Churchill, London, 1956).
[6] Strominger, J. L., Maxwell, E. S., Axelrod, J., and Kalckar, H. M., *J. Biol. Chem.*, **224**, 79 (1957).

The Pasteur Effect in a Respiration-deficient Mutant of Baker's Yeast

The respiration-deficient mutant of baker's yeast, *Saccharomyces cerevisiae R XII A*, induced by high-temperature cultivation, was used for examining the point of action of oxygen in the Pasteur effect. The mutant was identical with the *petite colonie* mutant described by Ephrussi[1] and Raut[2]. The argument was that, if oxygen acted directly on some enzyme involved in glucose degradation (for example, glyceraldehyde phosphate dehydrogenase), it would decrease the rate of glucose catabolism even in the mutant lacking essential components of the cytochrome system.

It was found that in the presence of glucose there was no demonstrable uptake of oxygen by the suspension and that the Q_{O_2} (= 100–130) was not affected by the introduction of oxygen into the suspension. The uptake of glucose, as measured by

Table 1. Inorganic Phosphate and Labile Phosphate Levels in the Respiration-Deficient Mutant (mgM. Phosphorus/mgM. Dry Weight ± *S.E.*)

Incubation conditions	Inorganic phosphate	Labile phosphate
No substrate, anaerobically	4·24 ± 0·24	5·84 ± 0·31
No substrate, 10 min. aeration	5·63 ± 0·26	6·39 ± 0·67
5 per cent glucose, anaerobically	2·37 ± 0·23	7·15 ± 0·71
5 per cent glucose, 10 min. aeration	2·40 ± 0·21	7·26 ± 0·75

quantitative analysis as well as by distribution of radioactivity following application of universally labelled ^{14}C-glucose, revealed no differences between aerobic and anaerobic conditions. As another criterion of the Pasteur effect, the change of inorganic phosphate-level was examined. Here again no change due to oxygen could be observed to take place in the steady-state level in the presence of glucose (Table 1).

If these results can be generalized they may serve as a weighty support for the theory that oxygen brings about the Pasteur effect not by affecting directly any enzyme involved in the anaerobic breakdown of glucose but rather by making it possible for other catabolic pathways to function (much in line with Lynen's views[3,4]).

It was observed, however, that under conditions when no substrate was present in the medium, oxygen was effective in producing changes in the amounts or, at any rate, in the distribution of some metabolically active components of the mutant cell. Some of these changes (for example, in the penetration of free glucose into the cell) are dealt with elsewhere[5]. It was found here that oxygen decreased the level of inorganic phosphate in the absence of glucose, with simultaneous production of labile phosphate bonds (Table 1), the process being completely blocked by 10^{-4} *M* potassium cyanide but only partly inhibited (at most by 20 per cent of the steady-state level change) by 5×10^{-4} *M* 2,4-dinitrophenol. The generation of high-energy phosphate bonds was accompanied by only a minute oxygen consumption (Q_{O_2} = 0·25–0·32; Q_{CO_2} = 1·09–1·48) so that the apparent phosphorus : oxygen ratio reached values far exceeding those commonly reported for whole cells and even for purified enzyme systems. Thus endogenous phosphorylation in the mutant (and very likely in ordinary baker's yeast, ref. 6) appears to be qualitatively different from phosphorylation proceeding with glucose, and produces high-energy bonds at the expense of other energy sources (physicochemical state of proteins, nucleic acids?) than those involved in oxidative phosphorylation known heretofore.

Detailed results will be published in *Folia microbiologica*.

A. Kotyk

Laboratory for Cellular Metabolism,
Institute of Biology,
Czechoslovak Academy of Sciences,
Prague.

[1] Ephrussi, B., *Pubbl. Staz. zool. Napoli Supp.*, 50 (1950).
[2] Raut, C., *Exp. Cell Res.*, **4**, 295 (1953).
[3] Lynen, F., Netter, K. J., Schuegraf, A., and Stix, G., *Eighth Colloquium Gesellschaft physiol. Chemie* (Springer-Verlag, Berlin, 1958).
[4] Lynen, F., *Ciba Foundation Symp. Regulation Cell Metabolism*, edit. by Wolstenholme, G. E. W., and O'Connor, C. M. (J. and A. Churchill, London, 1959).
[5] Kotyk, A., *Symp. Membrane Transport and Metabolism*, edit. by Kleinzeller, A., and Kotyk, A. (Publ. House Czechoslovak Acad. Sci., Praha, 1961).
[6] Stickland, L. H., *Biochem. J.*, **64**, 498 (1956).

Is *Mycobacterium phlei* Glutamotransferase endowed with Glutamine Synthetase Activity?

In a previous paper[1] we reported the finding of glutamotransferase (an enzyme catalysing the transfer of the γ-glutamyl residue of glutamine to hydroxylamine)[2] in cell-free extracts of *M. phlei*. The enzyme required the presence of manganese ions, which could not be substituted by magnesium ions. No glutamine synthetase (an enzyme catalysing the synthesis of glutamine from glutamic acid and ammonia) activity was found in the *M. phlei* preparations, when tested in the presence of magnesium ions under conditions optimal for this enzyme in preparations of bacterial[2], plant[3] and animal[4] origin. The *M. phlei* extracts possessed only traces, if any, of glutaminase activity and did not hydrolyse glutamohydroxamic acid at all. On the other hand, these preparations showed very high asparaginase activity, lacking any aspartotransferase and asparagine synthetase activities. Aspartohydroxamic acid was very strongly hydrolysed by the *M. phlei* extracts; however, this activity was dissociated from asparaginase activity. We have, therefore, concluded that in *M. phlei* the reactions of transfer, synthesis and hydrolysis are due to the action of different enzymes.

It was reported recently[5] that glutamine synthetase and glutamotransferase of sheep brain were activated by either manganese or magnesium. The *p*H optimum of the manganese activated synthetase was in the acid range (*p*H 4·5), while that of the magnesium reaction was 7·2. Increase of the cation concentration caused a shift to the left of the *p*H optima of the manganese-activated synthetase and transferase. Thus the same enzyme seemed to catalyse both the synthesis and transfer reactions.

In light of these findings, and in view of the fact that the *M. phlei* transferase showed a specific requirement for manganese, it was of interest to see whether this organism also possesses a manganese-dependent synthetase.

Table 1. Testing for Glutamine Synthetase Activity of *M. phlei* Extracts with Emphasis on Concentrations of Manganese, Magnesium and Hydrogen Ions

Reaction mixture No.	$MnCl_2$	$MgSO_4$	*p*H
1	$2·25 \times 10^{-3}$ *M*	—	4·5
2	$2·25 \times 10^{-4}$ *M*	—	5·0
3	$4·5 \times 10^{-4}$ *M*	—	5·5
4	$2·25 \times 10^{-4}$ *M*	—	6·0
5		$2·25 \times 10^{-3}$ *M*	6·0
6		$2·25 \times 10^{-3}$ *M*	6·5
7		$2·25 \times 10^{-3}$ *M*	7·0
8		$2·25 \times 10^{-3}$ *M*	7·5
9		$2·25 \times 10^{-3}$ *M*	8·0

The reaction mixture contained: L-glutamic acid, $2·25 \times 10^{-2}$ *M*; hydroxylamine sulphate, $1·10 \times 10^{-2}$ *M* (calculated as NH_2OH); ATP, $2·5 \times 10^{-3}$ *M*; $MnCl_2$ and $MgSO_4$ as indicated; *p*H as indicated; *p*H values below 7·0 were obtained by the use of acetate buffer, 0·1 *M*, while *tris* (hydroxymethyl) aminomethane buffer, 0·05 *M*, was used for *p*H values of 7·0 and above; bacterial extract, 9·1 mgm. protein. Final vol., 2 ml. All solutions added were adjusted to the appropriate *p*H with sodium hydroxide. Experiments were performed in the absence and presence of L-cysteine, 0·04 *M*, which was added before sonication. The mixtures were incubated at 37° for 90 and 180 min.

The experiments were performed with cell-free extracts at various manganese, magnesium and hydrogen-ion concentrations as indicated in Table 1. All the experiments invariably gave negative results: no synthetase activity could be detected under any of these conditions employed. With manganese, but not with magnesium, these extracts showed high glutamotransferase activity as already reported[1]. The results confirm our previous assumption, that the glutamotransferase of *M. phlei* is not associated with any synthetase activity.

Y. S. Halpern
Nathan Grossowicz
Department of Bacteriology,
Hebrew University–Hadassah Medical School,
Jerusalem.

[1] Grossowicz, N., and Halpern, Y. S., *J. Biol. Chem.*, **228**, 843 (1959).
[2] Fry, B. A., *Biochem. J.*, **59**, 579 (1955).
[3] Elliott, W. H., *J. Biol. Chem.*, **201**, 661 (1953).
[4] Speck, J. F., *J. Biol. Chem.*, **179**, 1387, 1405 (1949).
[5] Greenberg, J., and Lichtenstein, N., *J. Biol. Chem.*, **234**, 2337 (1959).

PHYSIOLOGY

Flow of Portal and Hepatic Blood in Normal and Cirrhotic Liver

Hepatic blood-flow measured by the bromsulphthalein method, the colloidal radiogold method, or other methods is the sum of both portal blood-flow and hepatic arterial blood-flow. As to the relative portal and arterial blood-flow, one-third to one-fourth of the total hepatic blood-flow was estimated, in animal experiments, to be derived from the hepatic artery under basal conditions[1]. In some cases with cirrhosis of the liver, in which portocaval shunting operations were performed or portal venous collaterals were accessible, 25–75 per cent or 54 per cent of the total hepatic blood-flow was estimated to be from the hepatic artery[2,3]. It is desirable to develop a new method which enables the actual measurement of the portal blood-flow and the hepatic arterial blood-flow in normal subjects and cirrhotic patients, but there has been no report except that of Ueda[4].

Ueda was the first to describe a method of measuring portal and hepatic arterial flow of blood in clinical cases. His method was based on the fact that the hepatic arterial blood was diluted with the portal blood when the hepatic arterial blood appeared in the hepatic veins, and that a dye concentration curve of the peripheral arterial blood could be a substitute for that of the hepatic arterial blood. Relative portal and arterial flow of blood was calculated from T_{1824} concentration curves of the peripheral arterial blood, and of the hepatic venous blood after the injection of T_{1824} into the cubital vein. The ratio of the hepatic arterial blood-flow to the total hepatic blood-flow was calculated as the ratio of the area of the first (hepatic arterial) component of the hepatic venous concentration curve to that of the peripheral arterial concentration curve.

This method is theoretically attractive. However, it involves a difficulty in the actual measurement. According to our experience, the differentiation between the first (hepatic arterial) component and the second (portal) component in the hepatic venous curve, which is needed for the calculation, is impossible by the original method. Hence, we attempted to improve the method, and were successful in the actual measurement of the portal and hepatic arterial flow of blood by our improved method.

Instead of the original method of injecting a T_{1824} solution into the cubital vein, 50–100 μc. of radioactive iodinated human serum albumin is injected into the pulmonary artery by means of a venous catheter, and blood is taken at successive intervals of 2–3 sec. from the hepatic vein through a hepatic venous catheter and also from an arterial needle placed in the brachial

artery. Injection into the pulmonary artery serves to reduce diffusion of the injected material before it reaches the hepatic vein. Radioactive iodinated human serum albumin is used, because a major part of T_{1824} which is not yet bound with serum albumin binds with proteins of liver cells and does not appear in the hepatic vein.

The portal flow of blood (P) and the hepatic arterial flow of blood (A) are calculated from the first half-area of the curve of radioactivity in the brachial artery (a), the first half-area of the first (hepatic arterial) component in the hepatic venous radioactivity curve (b), and the total hepatic blood-flow (T), according to the method of Ueda (Fig. 1).

$$\frac{P}{A} = \frac{a}{b} - 1$$

$$P + A = T$$

The total hepatic flow of blood is determined by the method of Bradley *et al.*[5].

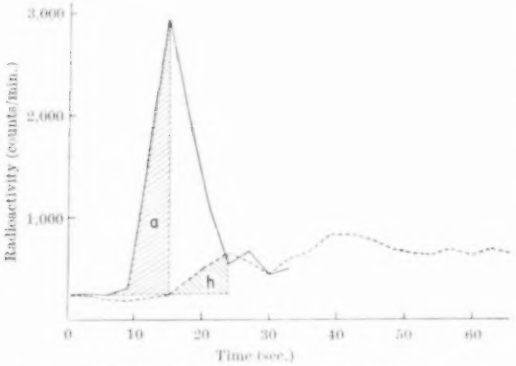


Fig. 1. Radioactivity in blood of a brachial artery (——) and hepatic vein (– – –) in a case with mild cirrhosis of the liver

In five normal subjects the portal flow of blood was 606–915 c.c./min./m.² (66–83 per cent of the total hepatic blood-flow), and the hepatic arterial blood-flow 142–418 c.c./min./m.² (17–34 per cent). In seven cases with cirrhosis of the liver, on the other hand, portal flow of blood was 203–802 c.c./min./m.² (41–79 per cent), and the hepatic arterial blood-flow 179–355 c.c./min./m.² (21–59 per cent).

Thus about one-fourth of the total hepatic flow of blood is derived from the hepatic artery in normal subjects, and the decrease of the total hepatic flow of blood in cirrhosis of the liver is ascribed mainly to the decrease of the portal flow of blood. These results are in agreement with the previous assumption based on the animal experiments and on the results of special cases with cirrhosis of the liver.

T. Nakamura
S. Nakamura
T. Kaneko

First Department of Internal Medicine,
Tohoku University School of Medicine,
Sendai.

[1] Grindlay, J. H., Herrick, J. F., and Mann, F. C., *Amer. J. Physiol.*, **132**, 489 (1941).
[2] Redeker, A. G., Geller, H. M., and Reynolds, T. B., *J. Clin. Invest.*, **37**, 606 (1958).
[3] Myers, J. D., and Durham, N. C., *J. Clin. Invest.*, **29**, 836 (1950).
[4] Ueda, H., *Nihon Naikagakkai Zasshi (J. Japan. Soc. Int. Med.)*, **42**, 591 (1953).
[5] Bradley, S. E., Ingelfinger, F. J., Bradley, G. P., and Curry, J. J., *J. Clin. Invest.*, **24**, 890 (1945).

Purification of the Toxic Fractions from *Ascaris lumbricoides* and their Effect on the Guinea Pig

Shinamura and Fuji[1], Bier[2] and Rocha e Silva and Graña[3] were able to isolate from *Ascaris lumbricoides* an extract very active in producing an anaphylactic-like shock in guinea pigs and in dogs. On the other hand, Machebouef and Mandoul[4] showed a similar activity in extracts from *Ascaris megalocephala*. Nakajima[5], after heating at 80° C. an aqueous extract of *Ascaris lumbricoides*, purified it by alcoholic precipitation, obtaining an active fraction containing N and P. Recently, Högberg *et al.*[6], using 'Amberlite *IRC*–50' (*XE*–64), obtained a quite active fraction which released histamine from the perfused paw of the cat. The present communication describes the further purification and chemical analysis of the active fractions, and the effect of these fractions on the guinea pig.

Ascaris lumbricoides, collected from hogs, was treated by the method described by Rocha e Silva and Graña[3]. This extract, called fraction SB_1, was further purified by precipitation with ammonium sulphate to saturation at *p*H 5·2. The supernatant fluid was dialysed against distilled water for 48 hr., and alcohol then added to 95 per cent. The alcoholic precipitate, dissolved in distilled water, was run through a column of hydroxyapatite. The most active fraction was eluted with phosphate buffer, *p*H 7·5, 0·01 *M*; under these conditions the column did not retain the active fraction. Elution with higher ionic strengths gave other protein peaks which contained some activity, and these fractions are still being studied in our laboratory. After dialysis for 48 hr. against distilled water, the active fraction obtained from the column was precipitated by adding alcohol to 95 per cent and dried *in vacuo*. This fraction was named SB_4. The chemical analysis of these two fractions is shown in Table 1. Passing it again through a column of 'Amberlite *IRC*–50' or zone electrophoresis on starch showed only one protein peak.

Table 1. Chemical Analysis of Fractions SB_1 and SB_4 from *Ascaris lumbricoides*

	Protein (per cent)		Reducing sugars (per cent)*	Nitrogen (per cent)	Phosphorus (per cent)
	(Lowry)	280 mμ/260 mμ			
SB_1	27·4	33·3	21·3–23·3	7·7–8·7	1·18
SB_4	7·6	7·7	42	3·4–4·3	1·80

* Measured as glucose

From our results the active fraction of the *Ascaris lumbricoides* seems to be a complex substance containing sugars and protein.

For the biological assay of the *Ascaris* fractions, guinea pigs weighing 200–400 gm. were used. Intravenous injection of the active fractions caused in the majority of the animals an anaphylactic-like reaction. The activity of the fractions was determined by recording the ratio of deaths to survivals in a group of 6 animals, as shown in Table 2. Table 2 also shows an increase in the carbohydrate with a simultaneous decrease in the protein content when the SB_1 is purified.

Histological examination of the lungs of the animals which died in shock showed a reduction of 70–80 per cent in the number of the mast cells when compared with control animals. Furthermore, mast cells damage very similar to that noted by Mota and

Table 2. Relation of Dose (mgm./100 gm.) to Mortality for Guinea Pigs injected with SB_3 and SB_4 Fractions

Ascaris fractions	Total weight (μgm.)	Protein (μgm.)	Residue including glucide (μgm.)	Mortality ratio
SB_3	50	15	35	0/6
	133	40	93	3/6
	200	60	140	5/6
SB_4	132	10	122	4/6
	264	20	244	5/6

Vugman[7] in anaphylaxis was observed. Perfusion of the isolated guinea pig lungs with 20–30 μgm. of SB_4 released histamine ranging from 1·35 to 5·85 μgm. The addition of 1–5 μgm. of the fraction SB_4 to the perfusing bath containing the guinea pig ileum evoked a strong contraction. A second addition of the same dose of SB_4 was either ineffective or produced a smaller effect, followed by a refractory state on further addition of the fraction. These experiments suggest that the ileum was desensitized by the first addition of SB_4. This desensitization was observed in 27 out of 30 different guinea pig ilea tested. Fig. 1 illustrates one of these experiments. On the other hand, when 7 guinea pigs were injected with sub-lethal dose of SB_4, and two days later the ilea were suspended in an organ-bath and tested with SB_4 as described above, none of them showed any response when the *Ascaris* fraction was added to the bath. On the basis of these findings, it is suggested that the guinea pigs are naturally sensitized to *Ascaris lumbricoides*.

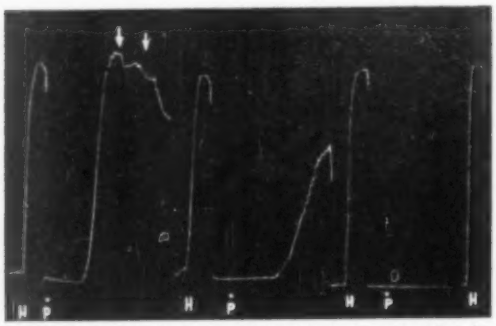


Fig. 1. Guinea pig ileum suspended in 10 ml. atropinized Tyrode solution. Effect of 5 μgm. fraction SB_4 (*P*) and 0·1 μgm. of histamine (*H*). The arrows indicate washings with Tyrode solution

We thank Prof. J. Baeta Vianna for his interest and helpful suggestions. The work was supported in part by funds received from the Rockefeller Foundation.

G. Gazzinelli
M. M. Guia
A. G. A. Neves
J. Pudles*

Department of Biochemistry,
W. T. Beraldo
W. Dias da Silva

Department of Physiology, Faculty of Medicine,
Belo Horizonte, Brazil.

* Fellow from the C.N.Pq. Brazil.

[1] Shinamura, T., and Fuji, N., *J. Coll. Agric.*, **4**, 189 (1917).
[2] Eter, O., cited by Rocha e Silva and Graña, A. (ref. 3).
[3] Rocha e Silva, M., and Graña, A., *Arch. Surg.*, **52**, 523 (1946).
[4] Machebouef, M., and Mandoul, R., *C.R. Soc. Biol.*, **130**, 1032 (1939).
[5] Nakajima, M., *Yokohama Med. Bull.*, **5**, 10 (1954).
[6] Högberg, B., Thufvesson, G., and Uvnas, B., *Acta Physiol. Scand.*, **38**, 135 (1956).
[7] Mota, I., and Vugman, I., *Nature*, **177**, 427 (1956).

Cholinergic Activity of Hyoscyamine

Many former and recent investigations, employing various clinical and experimental tests[1–4], have already revealed the synergic action of small atropine doses with acetylcholine. We were able to demonstrate quite an unexpected experimental correlation between hyoscyamine and cholinergic activity.

Fig. 1 shows an illustrative example of this correlation selected from a lot of thirty similar experiments. The 2 m. recti abdominis of a frog are suspended in Ringer fluid and their motor reactions are recorded on a slow-moving drum, one above the other, with a pair of vertical writing, isotonic levels having a two-fold amplification. The lower muscle only receives every 15 or 30 min. successive geometrically increasing, hyoscyamine concentrations which increase in geometrical progression with ratio 10 starting with C_{20} (C_{20} stands conventionally for $3{\cdot}16 \times 10^{-20}$ *M* and generally C_n for $3{\cdot}16 \times 10^{-n}$ *M*; D_n stands for $5{\cdot}62 \times 10^{n}$ *M*; 3·16 and 5·62 are the antilogarithms of 0·500 and 0·750 respectively). The first slightly active concentration (mark 7) is C_{14}. The next one gives a contraction of 5 mm., the third one 1·3 mm., the fourth only 0·1 mm. The concentration C_{10} produces no effect (mark 11). The same concentration, C_{10}, is also added to the upper muscle, also with no effect. At mark 12, the two muscles are washed three times and their responses to acetylcholine concentrations C_8 and C_6 tested. Both muscles show normal reactivity.

They are again washed and, after relaxing to their initial length, both receive paraoxon in concentration D_6 at mark 16, to block their acetylcholine esterase. At mark 17, the lower muscle receives again the series of increasing hyoscyamine concentrations, starting with C_{17}. The first contractile reaction arises at C_{14} and the higher concentrations increase the contraction

Fig. 1. Cholinergic activity of hyoscyamine

which is maximal at C_{10} (mark 24). At the same mark, the upper muscle receives hyoscyamine C_5 with practically no effect.

In my experiments the lowest active dose of hyoscyamine was C_{17}. It can be seen that hyoscyamine in very low concentrations contracts the frog's rectus, whereas concentrations of ten thousand up to one billion times greater fail to do so.

The amplitude of the maximal contraction produced by hyoscyamine increases by 6–10 times after paraoxon and is generally higher than that elicited by acetylcholine in concentration C_6 on untreated muscle. Concentrations of hyoscyamine, one million to one billion times higher than the threshold ones, are ineffective on treated, as well as on untreated, rectus muscles.

The contractions produced by small hyoscyamine concentrations are relaxed by stronger concentrations of this same alkaloid, by D-tubocurarine, in concentration C_6, and by magnesium chloride of concentration C_2.

These results suggest strongly that hyoscyamine acts on the rectus muscle as a contracting drug through a cholinergic mechanism, possibly by setting free an amount of acetylcholine at the level of its action. The closer pharmacological analysis of the site of this effect, details of which will be published elsewhere, demonstrates that these small concentrations of hyoscyamine act at the level of the neuromuscular junction and not on the contractile substance itself.

Methylatropine and scopolamine have no such effects. Other drugs may also act by releasing acetylcholine through a similar mechanism. I demonstrated it for barium chloride in concentrations between C_4 and C_3 and for neostigmine, in concentrations C_6 and C_5.

A. Teitel

Pharmacological Laboratory,
Medicine Faculty,
Bucharest.

[1] Kaufmann *et al.*, *Wiener Klin. Woch.*, 29 (1913).
[2] Danielopolu *et al.*, *Com. Acad. R.P.R.*, **1**, 797 (1951).
[3] Lüllmann, H., *et al.*, *Arch. Exp. Path. Pharm.*, **215**, 8 (1952); **216**, 152 (1952).
[4] Hazard, R., *et al.*, *Arch. Int. Physiol.*, **120**, 369 (1959).

Serum Changes in the Rat following Oral Administration of Cadmium

The comparatively sudden and pronounced drop in hæmoglobin-levels and the resultant anæmia following oral administration of low doses of cadmium to rats has been reported by several workers[1–4]. Starch-gel electrophoresis was performed on the serum proteins of rats similarly dosed, using the apparatus described by Smithies[5], and a modification of the discontinuous buffer system described by Poulik[6], in which low melting point *tris*(hydroxymethyl)-aminomethane (m.p. 125° C.) was used instead of the usual form (m.p. 171° C.).

Sixteen male rats, Chester Beatty strain, aged three weeks and weighing 80–100 gm., were fed on diet 41*B* and allowed unlimited drinking water, containing 50 p.p.m. of cadmium as cadmium chloride. Blood specimens were taken from the tail at fortnightly intervals by rota, and severe anæmia was confirmed after four weeks. Despite continued oral administration of cadmium for a further three months, the degree of anæmia remained constant. Certain modifications of the normal serum protein pattern were observed after a similar time, but again, despite continued dosing, no further change was observed.

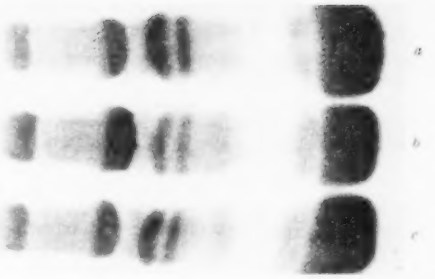


Fig. 1. Starch-gel electrophoresis pattern of the sera of rats given drinking water containing 50 p.p.m. of cadmium as cadmium chloride for four weeks. *a*, Cadmium rat serum; *b*, normal rat serum; *c*, cadmium rat serum. *A*, Unknown; *B* and *C*, transferrin bands

Two abnormalities in the serum protein pattern were seen to occur (Fig. 1). The component at point *A* was considerably diminished in the cadmium-dosed rats, compared with the control rats. The components at points *B* and *C* were noticeably enhanced by comparison with the controls and the possibility that they might be transferrin bands was examined, using the method of Giblett, Hickman and Smithies[7]. 1 µc. of radioactive iron-59 (as ferric chloride) was added to 0·2 ml. of normal rat serum and the specimen was subjected to starch-gel electrophoresis as before. The gel was sliced into two wafers, one slice being stained with a saturated solution of naphthalene black 10*B* 200 in methanol/water/glacial acetic acid (5:5:1) and the other slice, sealed in 'Saran Wrap', was placed in contact with Kodak 'No Screen' X-ray film for 12 hr., followed by development for 3 min. in Kodak *D8* developer. Comparison of the stained gel and the final X-ray film showed that bands *B* and *C* had bound the radioactive iron exclusively. The result was confirmed by sectioning the starch block into the various bands, digesting the sections in 50 per cent nitric acid containing added carrier iron, and finally assaying the activity using an *M6H* liquid counter.

Benzidene staining of the gel revealed the presence of hæmoglobin in the space between the bands *A* and *B*, and further investigation indicated a 'ghost' band in this area, which was apparently the component which reacted positively to the stain.

Estimations of the copper oxidase-levels of the sera by the method of Ravlin[8] indicated no significant difference between the cadmium-dosed rats and the controls.

D. J. Lawford

Department for Research in Industrial Medicine
(Medical Research Council),
The London Hospital,
London, E.1.

[1] Wilson, R. H., DeEds, F., and Cox, Jun., A. J., *J. Pharmacol.*, **71**, 222 (1941).
[2] Fitzhugh, O. G., and Meiller, F. H., *J. Pharmacol.*, **72**, 15 (1941).
[3] Ginn, J. T., and Volker, J. F., *Proc. Soc. Exp. Biol.*, **57**, 189 (1944).
[4] Decker, L. E., Byerrum, R. U., Decker, C. F., Hoppert, C. A., and Langham, R. F., *Arch. Industr. Health*, **18**, 228 (1958).
[5] Smithies, O., *Biochem. J.*, **61**, 629 (1955).
[6] Poulik, M. D., *Nature*, **180**, 1477 (1957).
[7] Giblett, E. R., Hickman, C. G., and Smithies, O., *Nature*, **183**, 1589 (1959).
[8] Ravlin, H. A., *Lancet*, i, 726 (1956).

Absorption of Amniotic Fluid in the Gut of Fœtal Sheep

SWALLOWING movements are known to be made by the fœtus *in utero*, but the ability of the gut to absorb material from the amniotic fluid has received little attention. This latter aspect has been investigated in fœtal sheep over the age-range 80–145 days (full term).

Under spinal anæsthesia and sedation with sodium thiopentone the fœtus was exposed by Cæsarian section and its abdomen opened. Electrical potential differences were measured between gut contents and fœtal extracellular fluid at various levels, using a Vibron 33*B* electrometer, calomel electrodes and 3 *M* potassium chloride in agar salt bridges. Representative segments of the gut were used to study the absorption of amniotic fluid to which polyethylene glycol, mol. wt. 3,300–4,000, was added to serve as volume marker[1]. The segments used were abomasum, jejunum, ileum and colon; approximately 8 cm. lengths of these latter three segments were used. Each segment, isolated by ligation, with intact blood supply, was flushed and filled with the labelled amniotic fluid and then left unexposed for 1–3 hr. The initial volume was calculated from the final weight of the contents and the change in concentrations of polyethylene glycol.

All significant potential differences (greater than ± 3 mV.) showed the gut lumen to be electrically negative with respect to the fœtal extracellular fluid at all ages studied. The abomasal potential difference was 14 mV. at 80 days, 21 mV. at 107 days and 26–30 mV. after 120 days. The potential difference across the small intestine was close to zero prior to 120 days, after which values of 4–10 mV. were obtained. The potential difference across the colon was close to zero at 80 days. From 120 days the transcolon potential-difference was 4–24 mV. These values may be compared with those obtained in the adult which were of the same sign: abomasum 40 mV., small intestine 10–14 mV., colon 15 mV.

Control experiments on single segments showed that the recovery of polyethylene glycol using a turbidimetric method[2] was of the order of 60–80 per cent over the experimental period. Calculations based on an assumed recovery of 60 per cent showed a net absorption of water, sodium and fructose from all segments at all ages studied. The amount of water absorbed from any segment was greater than could be accounted for by the hypotonicity[3] of the amniotic fluid. Sodium absorption occurred against a gradient of concentration and electrical potential. Absorption of fructose took place down a concentration gradient (140–500 mgm./100 ml. in amniotic fluid, 80–120 mgm./100 ml. in fœtal plasma), the fructose concentration in the gut decreasing. The results obtained for water absorption were extrapolated to the whole gut. From this it was computed that the 100–110 day fœtus absorbed fluid at a rate of 120 ml. per day. At 120 days this was about one litre, falling to 500 ml./day at term. The total volume of fluid absorbed from 80 days to term is about 32 litres, which is of the same order of magnitude as the volume of urine produced during this time (about 40 litres[4]). At 100 days fructose absorption occurred such that 6·7–10·7 per cent of the fructose introduced into the small intestine was absorbed in 1 hr., 12·6 per cent/hr. being absorbed from the colon. At 107 days the rate of fructose absorption was 9·0 per cent/hr. from the abomasum, 26–40 per cent/hr. from the small intestine and 46–47 per cent/hr. from the colon.

The results suggest that absorptive powers of the gut are retained in this species from at least 80 days. The gut is capable of absorbing a considerable volume of amniotic fluid with active sodium absorption probably accounting for much of the water absorption. Fructose absorption occurs at a high rate, and this may be of some nutritional significance to the fœtus. The fœtal abomasum appears to bear a functional similarity to the stomach of the fœtal rabbit in its capacity to absorb sodium actively[5].

This work was aided by an M.R.C. grant to Prof. A. St. G. Huggett and a grant to one of us (G. H. W.) from the Central Research Fund, University of London. We thank the Shell Chemical Co., Ltd., for donating the polyethylene glycol.

G. H. Wright
D. A. Nixon

Physiology Department,
St. Mary's Hospital Medical School,
Paddington, London, W.2.

[1] Sperber, I., Hyden, S., and Ekman, J., *LantbrHögsk. Ann.*, **20**, 337 (1953).
[2] Hyden, S., *LantbrHögsk. Ann.*, **22**, 139 (1955).
[3] Alexander, D. P., Nixon, D. A., Widdas, W. F., and Wohlzogen, F. X., *J. Physiol.*, **140**, 1 (1958).
[4] Alexander, D. P., Nixon, D. A., Widdas, W. F., and Wohlzogen, F. X., *J. Physiol.*, **140**, 14, (1958).
[5] Wright, G. H., *J. Physiol.*, **155**, 24 *P* (1960).

Spontaneous Potentials from Explants of Chick Cerebral Hemisphere (Telencephalon) in Tissue Culture

USING techniques and supernatant similar to those used to demonstrate spontaneous potentials from explants of chick embryo cerebellum in tissue culture in Kahn tubes[1], spontaneous potentials have been demonstrated in explants from the telencephalon of 11-day chick embryo brain. The explants were thin slices of the full thickness of the lateral aspect of the telencephalon. The control used was dead chick cerebellum tissue (explanted into a Kahn tube in the same manner as the telencephalic tissue and then killed by heat). The Kahn tube containing the control tissue was placed side by side with the living culture material in the same incubator with identical amplification and recording apparatus. The living brain tissue gave the same form and magnitude of potentials on every recording channel which was tried; whereas the control tissues gave no potentials on any channel.

The form of the potentials are shown in Fig. 1 (26 hr. in culture). The typical activity is a combination of series of spikes of varying complexity. The simplest of these spike potentials arises sharply from the background and has a relatively uncomplicated form and an amplitude of between 20 and 30 μV. The time-interval between them varies somewhat but many recur at nearly 16½ sec. intervals. A second and more complex form is seen to occur almost independently of this first type and consists of a group of smaller potentials having amplitudes between 10 and 15 μV. Each group lasts about 7 sec. and they are about 2 min. apart. This behaviour is unlike the behaviour of spontaneous potentials already reported from explants of cerebellum and medulla oblongata[1,2], but has some similarity to that reported from explants of human cerebellum[3]. The explant continued to show this type of spontaneous electrical potentials until

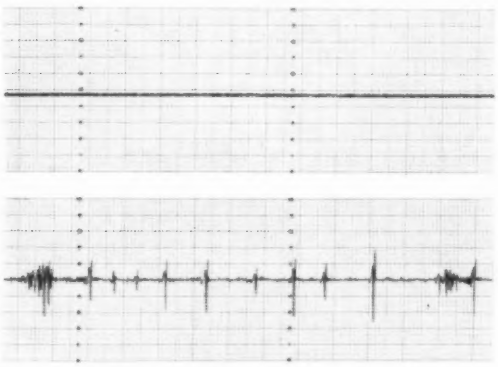


Fig. 1. Lower trace. Spontaneous potentials from an explant of 11-day chick telencephalon 26 hr. after explantation. Vertical lines, 4 sec. apart. Amplitude scale, distance between two horizontal lines equals 1½ μV. The photograph embraces one of the groups of potentials described in the text. Potentials at right-hand side of trace occurred before those at left-hand side. Upper trace. Control of dead cerebellar tissue under identical conditions with identical time and amplitude scales

after 72 hr. in culture. No record of spontaneous potentials from foci in the telencephalon in tissue culture has been found in the literature. Further investigations on these potentials are now in progress.

This work was done under a U.S. Navy Contract, *NONR* 1598 (04).

A. W. B. Cunningham
Tissue Dynamics Laboratory,
Pathology Department,
University of Texas Medical Branch,
Galveston, Texas.

[1] Cunningham, Dougherty and Rylander, *Nature*, **186**, 477 (1960).
[2] Cunningham, A. W. B., *Naturwiss.*, **48**, 104 (1961).
[3] *Nature* (in the press).

RADIOBIOLOGY

Increase of Aldolase Activity in Blood Serum following Irradiation

Sahasrabudhe, Nerurkar and Baxi[1] have found that 2 hr. after whole-body irradiation with 600 r., the aldolase activity of rat liver and scelet muscle decreased by 25–30 per cent.

Experiments were conducted to investigate whether this decrease of aldolase activity in liver and muscle makes any difference to the aldolase activity of blood serum.

As decrease of aldolase activity in the liver and muscle may influence aldolase activity in serum only after some time has elapsed and, as Albaum[2] described, decrease of aldolase activity in rabbit serum 6 hr. after whole-body irradiation with 750 r., the aldolase activity in the serum of guinea pigs was determined 2, 4, and 6 hr. after irradiation with 500 r. (Siemens Stabilivolt apparatus, 180 kV., 10 m.amp., 0·5 copper, 50 cm. distance without a tube, 36·3 r./min. dose-rate). The determinations were undertaken only in serum—in some cases in plasma—samples without any visible sign of haemolysis by the method of Tovarnicky and Voluyskaya[3] modified by Ananyev and Obouchova[4] using a Unicam *SP*. 500 spectrophotometer. Blood was withdrawn from the heart to avoid any admixture of tissue fluids.

The aldolase activity in the serum of 29 healthy guinea pigs was found to be 34·1 units (ranging from 22·7 to 45·0). In the plasma of 20 healthy animals it was found to be 33·1 units (ranging from 23·7 to 45·1).

The aldolase activity of serum samples 2, 4 and 6 hr. after irradiation was determined in the serum to 44, 21 and 22 animals. It was stated that the activity reached its maximum 4 hr. after irradiation (Table 1).

Table 1. Serum Aldolase Activity in Healthy and Irradiated Animals

Healthy animals	After irradiation of		
	2 hr.	4 hr.	6 hr.
34·1 (22·7–45·0)	34·9 (23·1–52·8)	64·4 (41·9–109·3)	53·3 (41·0–72·3)

These results show that aldolase released from liver, and perhaps muscle cells damaged by irradiation appears in serum 1–2 hr. later, that is, 3–6 hr. after irradiation. Thus the determination of aldolase activity in serum may help to detect radiation damage.

Our preliminary investigations on persons suffering from malignant tumour diseases and receiving therapeutic whole-body irradiation gave similar results with the remarkable difference, however, that while in guinea pig the same aldolase activity was found both in whole blood and in plasma, in man the aldolase activity in whole blood was several times greater than in plasma.

Results of investigations to elucidate the cause of this difference and to establish the connexion between dose of irradiation and increase of aldolase activity in serum will be published later.

B. Dalos
Central Institute for Radiobiology,
Budapest.

[1] Sahasrabudhe, M. B., Nerurkar, M. K., and Baxi, A. J., *Intern. J. Rad. Biol.*, **1**, 52 (1959).
[2] Albaum, H. G., *Rad. Res.*, **12**, 186 (1959).
[3] Tovarnicky, V. I., and Voluyskaya, E. P., *Labor. Delo.*, No. 5, 7 (1955).
[4] Ananyev, V. A., and Obouchova, V. P., *Vopr. Virus*, **3**, 119 (1958).

Effect on Biological Nitrogen Fixation of Nitrogen Gas treated with Ultra-violet Radiation

Many different theories on nitrogen fixation by *Azotobacter* cells have been presented, among them the proposition of Wilson and Burris[1] that the nitrogen molecules, which are absorbed and take part in the reactions leading to nitrogen fixation, are in an activated state. These authors also suggest that this activated form might comprise a molecule possessing an energy greater than some unknown critical value.

If this suggestion is valid, it might be possible to increase the degree of nitrogen fixation by increasing artificially the energy of the nitrogen gas.

We are recording here some experiments based on this assumption, using ultra-violet light as a means of bringing about an increase in the energy of the nitrogen gas.

The organism used was *Azotobacter vinelandii*, strain *O*. The bacteria were grown in a nitrogen-free medium[2], modified to contain 30 gm. of glucose instead of 10 gm. of sucrose. 0·05–0·2 l./min. of air was passed into the cultures through sintered glass cylinders 20 mm. long and 10 mm. thick (maximal pore diameter 40–60 μ). The rate of oxygen transfer for all the cultures was 150 m*M* O_2/l./hr., as measured by the sulphite method[3]. Separately, 0·4 l./min. of nitrogen was passed into the cultures through a

Table 1. The Effect of Irradiated Nitrogen Gas on Fixation of Nitrogen in Cultures of *Azotobacter vinelandii*, strain *O*

In each experiment eight cultures were run simultaneously under identical conditions except for the variance in the irradiation of the nitrogen gas. All the cultures were gassed with the same amount of nitrogen and at the same oxygen transfer-rate. The nitrogen fixed by the bacteria is expressed as mgm. nitrogen fixed per gm. glucose consumed. The increase of the nitrogen fixation obtained in cultures gassed with irradiated nitrogen gas is expressed in per cent of the mean value of the controls

Experiment	Control		Lamps								
			6 W.			15 W.			30 W.		
	mgm. N per gm. glucose	Mean value	mgm. N per gm. glucose	Mean value	Per cent increase of N	mgm. N per gm. glucose	Mean value	Per cent increase of N	mgm. N per gm. glucose	Mean value	Per cent increase of N
1	8·9 9·1	9·0	10·8 11·4	11·1	23·3	9·5 9·8	9·65	7·2	10·1 10·6	10·35	15·0
2	5·2 5·6	5·4	6·2 6·8	6·5	20·4	5·7 5·9	5·8	6·9	6·0 6·3	6·15	13·9
3	4·1 4·2	4·15	5·4 4·9	5·15	24·1	4·3 4·7	4·5	7·8	4·5 5·0	4·75	14·4
4	4·5 4·9	4·7	5·9 —	5·8	23·4	4·9 5·1	5·0	6·4	5·3 5·6	5·45	16·0
Total mean					22·8			7·1			14·8

capillary of 1·5 mm. diameter. Arrangements were made to wash the nitrogen with pyrogallol and water, and to dry the gas with calcium chloride before it entered the cultures.

Eight cultures were run simultaneously. In six of them the washed and dried nitrogen gas passed through glass-mantled ultra-violet lamps before entering the cultures. The ultra-violet lamps used were Philips' 6 W., 15 W. and 30 W. germicidal lamps marked *TUV* 6, *TUV* 15 and *TUV* 30. The distance travelled by the nitrogen through the capillary from the glass mantle to the open end was 150 mm. The end of the capillary tube was 50 mm. below the surface of the culture. Precautions were taken to avoid direct or indirect irradiation of the cultures by ultra-violet light. The cultures were run for 30 hr. and the growth estimated by dry-weight determinations. The glucose was determined by the anthrone method[4,5]. After digesting 1 ml. of each culture in sulphuric acid and oxidizing the solution with perchloric acid, the nitrogen was determined colorimetrically[6].

Using nitrogen gas, treated with ultra-violet radiation, as a partial nitrogen source, the nitrogen uptake increased by 7–23 per cent.

Table 1 shows that the 6-W. lamp increased the nitrogen uptake by 23 per cent, the 15-W. lamp by 7 per cent and the 30-W. lamp by 15 per cent, compared to the non-irradiated control cultures. Controls run in tubes fitted with the ultra-violet equipment—lighted but not flushed with nitrogen—gave roughly the same values as the ordinary growth tubes. In this case the nitrogen was added through an extra capillary.

Further work on the influence of irradiated gases on bacterial cultures is in progress in this laboratory and will be reported later.

We thank Miss K. Erixson for her helpful assistance and Statens Tekniska Forskningsråd for financial support.

B. Zacharias
C.-G. Hedén

Department of Bacteriology,
Karolinska Institute,
Stockholm.

[1] Wilson, P. W., and Burris, R. H., *Bact. Rev.*, **11**, 41 (1947).
[2] Nicholas, D. J. D., Fisher, D. J., Redmond, W. J., and Wright, M. A., *J. Gen. Microbiol.*, **22**, 191 (1960).
[3] Cooper, C. M., Fernstom, G. A., and Miller, S. A., *Indust. Eng. Chem.*, **36**, 504 (1944).
[4] Morris, D. L., *Science*, **107**, 254 (1948).
[5] Scott, jun., T. A., and Melvin, E. H., *Anal. Chem.*, **25**, 1656 (1953).
[6] Russel, Jane A., *J. Biol. Chem.*, **156**, 457 (1944).

HÆMATOLOGY

Hæmoglobins of Fœtal *C57BL* 6 Mice

The existence and nature of differences within species between adult and fœtal hæmoglobins have attracted much attention[1-7], but until very recently a distinct fœtal hæmoglobin type had not been demonstrated in the mouse. Filter paper[8,9], starch block[10] and starch-gel electrophoresis of hæmoglobins of adult mice from different inbred strains and inter-strain crosses have shown inherited strain specificity for either of two general types of electrophoretic pattern, 'diffuse' (two or more components) or 'single' (discrete single band). Tests of hæmoglobin of new-born mice from several different inbred strains have given electrophoretic patterns indistinguishable from those of adults of the same strain[11,12]. However, starch-gel electrophoresis of adult and fœtal hæmoglobins in the *CBA* strain of mouse has shown the presence in early fœtal samples of a slowly moving component which disappears after 15 days gestation[11]. The *CBA* adult mouse has 'diffuse' hæmoglobin (three bands on starch-gel)[11], which renders interpretation of variations in the pattern rather difficult. The concept of a change in hæmoglobin type in mid-fœtal life rather than at birth is sufficiently novel to warrant repetition of the experiment with more favourable genetic material. Starch-gel electrophoresis of hæmoglobin of adult *C57BL*/6 mice reveals the presence of only one component, which provides a simple background against which to analyse variations in pattern. The present communication is a comparison of the starch-gel electrophoretic pattern of hæmoglobin from early and late fœtal and adult *C57BL*/6 mice.

In obtaining timed fœtuses, duration of the mother's pregnancy was timed from observation of vaginal copulation plugs. Blood collected from each fœtus of a litter, by cutting across the umbilical cord, discarding the placenta, and transecting the thorax, was pooled in a Petri dish containing heparinized saline. The adult and fœtal samples thus obtained were subjected to identical means of preparation: the cells were washed twice in 0·9 per cent saline and the packed cells lysed with their own volume of distilled water. One volume of molar phosphate buffer, *p*H 6·8, was added to precipitate the stromal proteins and other contaminants. The mixture was then centrifuged and the clear hæmoglobin solution removed and stored in the cold until required. Each sample was used on the day on which it was prepared.

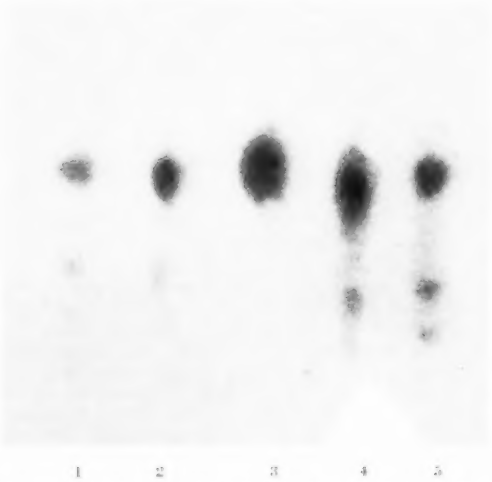


Fig. 1. Starch-gel electrophoresis (Poulik's discontinuous buffer system) of cyanmethæmoglobins prepared from 14-day fœtal and maternal *C57BL/6* blood and from a mixture of these two. 1, Fœtal; 2, mixture; 3, adult; 4, mixture; 5, fœtal

though results using hæmoglobins stored over several days in the cold showed that there was no appreciable alteration in the electrophoretic patterns.

The hæmoglobins were converted to the cyanmethæmoglobin forms and starch-gel electrophoresis carried out as described in a previous communication[11], except that a stronger solution of hæmoglobin was run for 4 hr. The gel was stained as before with an *o*-dianisidine hydrogen peroxide mixture.

The electrophoretic patterns of hæmoglobins obtained from several groups of fœtuses of all ages from 12 days of intra-uterine life to birth were studied. At 12 days each of four tested litters showed three components, with the slowest moving present in a concentration (judged by intensity of spots) at least equal to that of the most advanced component. At 13 days (four litters) the fastest moving component was increased in intensity while the slowest moving one was diminished ; at 14 days (three litters) this slowest moving spot was disappearing (Fig. 1), and at 15 days (three litters) it was not discernible. The second spot, which had also been diminishing, though more slowly, was still seen at 15 days but was scarcely visible at 16 days. From 17 days on to birth and into adult life, only the first rapidly moving component was seen. In order to determine whether the fastest-moving component observed in these early fœtal samples corresponded in any way with the single hæmoglobin found in the adult animal, an additional sample, composed of two parts of fœtal to one part of adult hæmoglobin, was applied to a gel together with the standard fœtal samples and maternal control. It was felt that if one of the fœtal components corresponded with the adult hæmoglobin, three spots would be visible in the mixture, whereas non-correspondence might result in an indistinct blur or the presence of four components. The mixture separated well into three components with the first component in line with the single adult spot of the control (Fig. 1). It seems, therefore, reasonable to assume that the first fœtal component has the same electrophoretic mobility as the adult component ; however, such mobility may be due to interaction between the two hæmoglobins and does not in itself demonstrate complete correspondence of the two.

These results are similar to observations previously made on the *CBA* strain of mouse[11] in that the adult pattern replaced the fœtal pattern in late intra-uterine life of the mouse rather than at birth as in many other species. The observed transition in hæmoglobin patterns occurred at a time when the proportion of nucleated red cells in the fœtal circulation falls rapidly. From the 14th day to the 16th day the numbers of nucleated erythrocytes have been reported to fall from 21 to approximately 1 per cent[13]. Although at the present time it is not possible to state any specific physiological reason for a shift in hæmoglobin pattern in mid-fœtal life, it is tempting to conjecture some relationship with the shift in proportion of nucleated erythrocytes.

We wish to thank Drs. E. S. Russell and K. B. Roberts for their generous help and advice. This investigation was supported by grant *E-76* to the Roscoe B. Jackson Memorial Laboratory from the American Cancer Society, and much of the work was carried out while one of us (J. B.) was holding a pre-doctoral fellowship from U.S. Public Health Service Grant *CRT-5013* to the Roscoe B. Jackson Laboratory.

J. Barrowman
M. Craig

Roscoe B. Jackson Memorial Laboratory,
Bar Harbor, Maine.

[1] Körber, E., inaugural dissertation, Dorpat (1866). Cited by Bischoff, H., *Z. Ges. Exp. Med.*, **48**, 472 (1926).
[2] Perrier, C., and Janelli, P., *Arch. Fisiol.*, **29**, 289 (1931).
[3] Betke, K., *Folia Haematologica*, **75**, 242 (1957).
[4] Hommes, H., Sangema-Drinkwaard, J., and Huisman, T. H. J., *Biochim. Biophys. Acta*, **20**, 564 (1956).
[5] Stein, W. H., Kunkel, H. G., Cole, R. D., Spackman, D. H., and Moore, S., *Biochim. Biophys. Acta*, **24**, 640 (1957).
[6] Wyman, J., Rafferty, J. A., and Ingalls, E. N., *J. Biol. Chem.*, **153**, 275 (1944).
[7] Helm, H. J., van der Visser, H. K. A., Vliet, G. van, and Huisman, T. H. J., *Clin. Chim. Acta*, **3**, 114 (1958).
[8] Ramney, H., and Gluecksohn Waelsch, S., *Ann. Human Genetics*, **19**, 269 (1955).
[9] Gluecksohn Waelsch, S., *J. Clin. Invest.*, **36**, 753 (1957).
[10] Russell, E. S., and Gerald, P. S., *Science*, **128**, 1569 (1958).
[11] Barrowman, J., and Roberts, K. B., *Nature*, **189**, 409 (1960).
[12] Gerald, P. S. (personal communication).
[13] Attfield, M., *J. Genetics*, **50**, 250 (1951).

PATHOLOGY

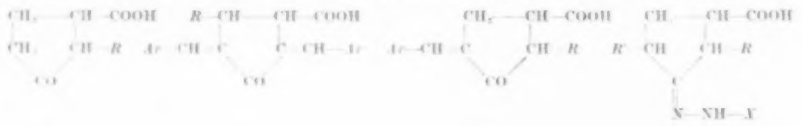
Anti-tumoral Action of New Sarcomycin Derivatives

The anti-tumour effect of sarcomycin-2 methylen *cyclo*-pentanon-3 carboxylic acid was reported so long ago as 1953 (ref. 1), and since then this substance has been widely employed for its broader chemotherapeutic effect on cancer. Recently one of us[2] proposed new procedures for the synthesis of compounds of sarcomycin type, and the preparation of several new sarcomycin derivatives is now possible.

In this communication we report on the action of some sarcomycin derivatives on the growth of the Ehrlich ascites tumour. The tetraploid Lipschutz IV strain of Ehrlich tumour has been used. The following procedure was adopted : from a donor mouse selected from mice with rapidly growing ascites, at 10 days after inoculation of cancer cells, 4 ml. of milky ascitic fluid were withdrawn. The cells were counted in a Spencer chamber and diluted with physiological saline buffered at *p*H 7. 0·2 ml. of the fluid

Table 1. Effect of Dihydrosarcomycin and its Derivatives on the Growth of Ehrlich Ascites Tumour

Amount of compound administered by a single injection: 4 mgm./20 gm. body-weight. Column *a*: survival number on 10 injected animals. Column *b*: percentage increase in body-weight. Figures in black type refer to animals of the control group



(I) (II) (III) (IV)

Compounds	Days after injection: 7		10		13		16	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*
Dihydrosarcomycin: I, $R = CH_3$	6	20	5	28	3	43		
	8	**16**	**7**	**30**	**4**	**49**		
SB_5: II, $R = H$; $Ar =$	7	13	4	47	2	47		
	8	**10**	**6**	**32**	**4**	**50**		
SB_6: II, $R = CH_3$; $Ar =$	8	12	4	30	1	50		
	7	**9**	**5**	**29**	**3**	**47**		
SB_7: II, $R = H$; $Ar = C_6H_4{-}OCH_3$ (4)	8	7	8	33	2	43		
	8	**10**	**7**	**29**	**4**	**46**		
SB_8: II, $R = CH_3$; $Ar = C_6H_4{-}OCH_3$ (4)	8	13	7	33	2	54		
	7	**9**	**6**	**31**	**3**	**50**		
SB_9: III, $R = C_2H_5$; $Ar =$	8	12	8	20	6	21	4	16
	9	**18**	**7**	**20**	**3**	**35**		
SB_{10}: III, $R = C_2H_5$; $Ar = C_6H_5$	8	13	8	19	7	22	6	29
	8	**9**	**7**	**20**	**3**	**40**		
SB_{11}: III, $R = C_2H_5$; $Ar = C_6H_4{-}OCH_3$ (4)	9	12	9	15	9	30	9	44
	8	**10**	**6**	**20**	**4**	**33**		
SB_{12}: III, $R = C_2H_5$; $Ar = C_6H_4{-}N(CH_3)_2$ (4)	10	10	9	15	9	35	9	44
	7	**13**	**6**	**27**	**3**	**40**		
SB_4: omodihydrosarcomycin: I, $R = C_2H_5$	6	29	5	46				
	8	**33**	**6**	**40**	**3**	**46**		
SB_{13}: III, $R = CH_3$; $Ar = C_6H_5$	6	24	6	50				
	7	**30**	**5**	**41**	**2**	**50**		
SB_{14}: III, $R = CH_3$; $Ar =$	6	22	6	57				
	8	**19**	**6**	**50**	**3**	**59**		
SB_{15}: III, $R = CH_3$; $Ar = C_6H_4{-}OCH_3$ (4)	7	21	7	57				
	7	**15**	**6**	**37**	**2**	**50**		
SB_{16}: III, $R = CH_3$; $Ar = C_6H_4{-}N(CH_3)_2$ (4)	7	23	7	23	7	23		
	7	**30**	**6**	**32**	**3**	**39**		
SB_{17}: IV, $R = H$; $R' = C_2H_5$; $X = CONH_2$	9	16	8	20	7	23		
	7	**13**	**6**	**22**	**3**	**28**		
SB_{18}: IV, $R = C_2H_5$; $R' = H$; $X = CSNH_2$	6	4	5	5	4	5	3	7
	7	**19**	**5**	**28**	**2**	**36**		
SB_{19}: IV, $R = C_2H_5$; $R' = H$; $X = C_6H_3(NO_2)_2$ (3.4)	7	30	6	41	4	62		
	7	**19**	**6**	**30**	**4**	**51**		
SB_{17}: IV, $R = H$; $R' = C_2H_5$; $X = CSNH_2$	6	10	6	42				
	8	**20**	**4**	**35**	**1**	**68**		
SB_{18}: IV, $R = CH_3$; $R = H$, $X = CSNH_2$	8	21	4	26				
	7	**21**	**4**	**30**	**1**	**49**		
SB_{20}: II, $R = C_2H_5$; $Ar = C_6H_4OCH_3$ (4)	8	21	6	48				
	8	**19**	**5**	**37**	**3**	**40**		
SB_{21}: II, $R = nC_3H_7$; $Ar = C_6H_4OCH_3$ (4)	9	18	6	58				
	8	**20**	**4**	**35**	**2**	**56**		

containing approximately 3 million cancer cells was injected intraperitoneally into the lower abdominal region into each of a number of young Swiss albino mice, weighing about 20 gm.

In each set of experiments the animals were divided in two groups, one treated with the compound, and the other used as control. The compounds to be tested were dissolved as calcium salt with saline and the resulting solution was adjusted to *p*H 7. Before the inoculation, the solutions were filtered through a Berkefeld candle, and aseptic precautions were maintained during the procedure. Each animal received one single administration of 4 mgm. immediately after the injection of cancer cells. The effectiveness of the compounds against the growth of the ascites tumour was recorded by the determination of survival-rate of treated animals, by measurements of the amount of ascites fluid after treatment (weighing the mice), and by cytological examinations of ascites tumour cells.

Table 1 shows the main results of the treatment with dihydrosarcomycin and with sarcomycin derivatives.

After early administration of the compounds, inhibition of ascites tumour is clearly shown, in some cases, on the basis of survival-rate and of increase of body-weight. The most effective compounds were found to be SB_5, SB_6, SB_7, SB_8 and SB_{15}, in each of which the CH_3CH_2 radical had been introduced; these are derivatives of omodihydrosarcomycin[3].

Further to clarify the chemotherapeutic action of those compounds, inhibition of the ascites tumour has been also evaluated by means of other parameters, as reported in Table 2.

The results in Table 2 clearly indicate that the sarcomycin derivatives really affect the growth of

Table 2

Compound	Mitotic rate	No. of cells/ml.	Mean total volume of fluid	Mean percentage living cells (Schrek)
Dihydro-sarcomycin	24	$5{\cdot}2 \times 10^5$	4·8 ml.	96
SB$_1$	20	$4{\cdot}6 \times 10^5$	4·2	94
SB$_2$	18	$5{\cdot}0 \times 10^5$	4·0	80
SB$_3$	14	$3{\cdot}1 \times 10^5$	2·5	46
SB$_4$	17	$4{\cdot}0 \times 10^5$	3·1	50
SB$_5$	15	$2{\cdot}9 \times 10^5$	2·9	28
Control	28	$7{\cdot}3 \times 10^5$	6·2	100

Ehrlich ascites tumour. It is also evident that the dihydrosarcomycin is less active than its derivatives.

It must be emphasized that in the evaluation of chemotherapeutic results, the dose and time of administration of the drug are very important. Under our conditions, one single dose only was given, whereas it is well known that a bigger effect can be obtained when several doses are given after the injection of cancer cells.

Detailed results of the anti-tumoral action of sarcomycin derivatives will be reported elsewhere.

A. Caputo
B. Giovanella
R. Giuliano

Regina Elena Institute for Cancer Research,
Rome,
and
Institute of Chemistry,
Pharmaceutics and Toxicology,
University of Bari, Italy.

[1] Okamy, I., Okuda, T., Takenchi, T., Nitta, K., and Umezawa, H., *J. Antibiot.*, **6**, 153 (1953).
[2] Giuliano, R., Di Fonzo, M., and Ermili, A., *Annali di Chim.*, **49**, 1607 (1959).
[3] Giuliano, R., Di Fonzo, M., and Artico, M., *Annali di Chim.*, **50**, 750 (1960).

Reversible Nature of Liver Cell Damage due to Carbon Tetrachloride as demonstrated by the Use of Phenergan

Rees, Sinha and Spector[1] have suggested a possible sequence of events in the rat liver following the administration of carbon tetrachloride. Thus at 6 hr. there is a large increase in liver fat and liver cell damage verging on necrosis. In addition, the hepatic enzymes, malic and *iso*citric dehydrogenase, can be detected in the blood. By 12 hr., histological examination shows early hepatic necrosis and massive fatty change, and glutamic dehydrogenase can be detected in the serum. As glutamic dehydrogenase is wholly a mitochondrial enzyme, this latter observation is indicative of mitochondrial injury. By 24 hr. the concentration of hepatic enzymes in the blood is maximal, as is the quantity of the fat in the liver. Histologically, there is widespread parenchymal cell necrosis. Recknagel and Anthony[2] have emphasized that the accumulation of fat in the liver occurs before mitochondrial injury becomes demonstrable by *in vitro* enzymological study, and have suggested that the initial effect of carbon tetrachloride on the liver occurs at about 3 hr.

In previous experiments it was found that the administration of phenergan ('Promethazine HCl') at 0 and at 6 hr. to animals poisoned with carbon tetrachloride modifies considerably the above sequence of events[1]. In rats receiving both phenergan and carbon tetrachloride, there was no significant liberation of hepatic enzymes into the blood and hepatic necrosis was almost absent in the first 24 hr. On the other hand, the hepatic fatty change was unaltered both in appearance and in quantity.

In the present investigation, these observations have been extended. It was found that if animals given carbon tetrachloride and phenergan at 0 and 6 hr. were given no further doses of phenergan in the period 24–48 hr., liberation of hepatic enzymes into the circulation was demonstrable from 24 hr. onwards, and by 48 hr. there was hepatic necrosis of the same order as found in the liver of a rat not treated with phenergan 24 hr. following poisoning with carbon tetrachloride. However, if the poisoned animals received additional treatment with phenergan during the 24–48 hr. period, hepatic necrosis and release of hepatic enzymes into the blood were prevented almost completely, and even at 72 hr. these changes were not observed (Table 1).

Table 1. Degree of Liver Necrosis and Level of Serum *iso*-citric Dehydrogenase following Carbon Tetrachloride Poisoning in Rats with and without Phenergan Treatment

Time after carbon tetrachloride poisoning (hr.)	Time of phenergan treatment (hr.)	Serum isocitric dehydrogenase (sd. oxygen per ml. per hr.)	Degree of necrosis	Comment
0	nil	1 (0·6–1·7)	0	—
24	nil	153 (144–180)	+ + + +	Active necrosis
24	0 and 6	12 (9–15)	+	—
48	nil	35 (28–40)	+ + + +	Healing necrosis
48	0 and 6	78 (60–84)	+ + + +	Active necrosis
48	0, 6, 24 and 30	11 (2–17)	+	—
72	nil	3 (1·5–4)	+ + +	Healing necrosis
72	0, 6, 24 and 30	1·0 (0·6–1·7)	+	—

The animals were dosed with 1·25 ml. carbon tetrachloride/kgm. body-weight. When phenergan treatment was given, the dose at 0 hr. was 25 mgm./kgm. body-weight and all subsequent dosage was at 12·5 mgm./kgm. body-weight level. Albino female rats (120–200 gm. body-weight) were used.

Active necrosis denotes areas of eosinophilic coagulative necrosis of liver cells. Healing necrosis denotes extensive infiltration of these areas by chronic inflammatory cells.

Since phenergan fails to prevent fatty accumulation in the liver, it is clear that the drug does not act by detoxicating carbon tetrachloride. In addition, the development of hepatic necrosis at 48 hr. after administration of carbon tetrachloride to animals given only two doses of phenergan would also suggest that phenergan had not detoxicated the carbon tetrachloride but rather prevented a secondary 'necrogenic' reaction in the liver cell.

Carbon tetrachloride reaches its maximum concentration in the liver about 3 hr. after administration, and thereafter the concentration[3] falls rapidly[4]. 24 hr. following poisoning with carbon tetrachloride, chemical estimation discloses that the concentration of the latter in the liver has dropped to zero, and in the present investigation using carbon-14 tetrachloride it was not possible to detect any radioactivity in the livers of animals 24 hr. after poisoning.

Thus, the delayed appearance of hepatic necrosis 24 hr. after administration of carbon tetrachloride in rats given phenergan at 0 and 6 hr. only occurs in the absence of carbon tetrachloride as demonstrable by chemical and radiochemical techniques.

The simplest explanation of these results is to assume that carbon tetrachloride irreversibly damages

a reaction that is non essential in the short term for the survival of the cell, and that as one consequence of this primary injury there is a secondary disturbance, for example, the entry of sodium and water into the cell. It is this secondary disturbance which is prevented so long as phenergan is present. It seems that the primary injury caused by carbon tetrachloride will continue in force, after its concentration has dropped, until the vital constituents of the damaged system are re-synthesized. This process appears to take up to 48 hr.

The hypothetical secondary disturbance could be associated with the breakdown of phosphoprotein, a system which Judah[5] has shown to be sensitive to the action of phenergan and has postulated as part of the mechanism controlling cellular water and electrolyte movements.

The reason for stating that the primary site of attack of carbon tetrachloride is a system not immediately essential for the life of the cell is that, in the presence of phenergan, the damage caused by carbon tetrachloride is reversible. It is clear that this conclusion carries with it some important implications, including therapeutical possibilities.

We are grateful to Sir Roy Cameron and Prof. C. Rimington for their advice and encouragement. One of us (K. R. R.) is indebted to the Medical Research Council for a grant for assistance.

K. R. Rees
W. G. Spector

Departments of Chemical Pathology and Morbid Anatomy,
University College Hospital Medical School,
London.

[1] Rees, K. R., Sinha, K. P., and Spector, W. G., *J. Path. Bact.* (in the press).
[2] Rees, K. R., and Sinha, K. P., *J. Path. Bact.*, **80**, 297 (1960).
[3] Recknagel, R. O., and Anthony, D. D., *J. Biol. Chem.*, **234**, 1052 (1959).
[4] Recknagel, R. O., and Litteria, M. O., *Amer. J. Path.*, **36**, 521 (1960).
[5] Judah, J. D., *Nature*, **185**, 390 (1960).

Alloxan and Hypersensitivity

During the course of another investigation, it was found that a diabetogenic dose of alloxan (175–200 mgm./kgm.)[1] protects approximately 50 per cent of rats sensitized to horse serum and later injected intravenously with this antigen. The time of death was lengthened in those rats suffering lethal shock. Controls consistently showed 0–10 per cent survivors.

Rats were of Sprague–Dawley strain, sensitized by a single intraperitoneal injection of a mixture of horse serum and *H. pertussis*. Alloxan was injected subcutaneously into the sensitized rats just prior to, or four days before, challenge with horse serum. Of the various routes tested, the subcutaneous route for injection of alloxan proved the least toxic. The purpose of this communication is to describe some aspects of the effect of alloxan on hypersensitivity reactions in the rat and guinea pig.

One unit of insulin, injected subcutaneously into alloxan-treated sensitized rats 1 hr. before challenge, partially reversed the protective effect of the alloxan. This amount of insulin also increased the speed with which death occurred in untreated sensitized controls (Fig. 1). Ganley[2] recently reported similar findings in mice.

In the guinea pig, alloxan injected either intraperitoneally or subcutaneously at 300 mgm./kgm. body weight four days prior to challenge reduced the size and intensity of the skin reaction to PPD in animals sensitized by injection of killed *M. tuberculosis* in paraffin oil emulsion. Long, Miles and Perry found a similar action of alloxan in guinea pigs infected with living *BCG*[3]. Alloxan did not protect against either 'immediate' or 'delayed' type anaphylaxis. However, it did appear to give protection during the first 24 hr. to the type of shock induced by intraperitoneal challenge with old tuberculin. Failure to protect from anaphylactic shock in the guinea pig may be due to the very swift occurrence of emphysema of the lungs and death from bronchospasm.

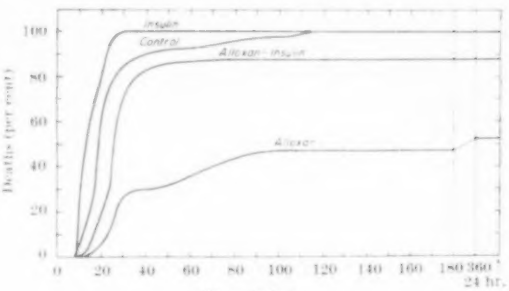


Fig. 1

The protective effect of a diabetogenic dose of alloxan in rat anaphylaxis and delayed skin hypersensitivity in the guinea pig, with its reversal in the rat by insulin, suggests the involvement of a lack of insulin or an excess of glucose. We have evidence that large amounts of glucose (4 gm./kgm. i.v.) injected intraperitoneally prior to challenge gives at least some degree of protection.

George E. Thompson

Wallace Laboratories,
New Brunswick,
New Jersey.

[1] Kass, E. H., and Waisbren, B. A., *Proc. Soc. Exp. Biol. Med.*, **60**, 303 (1945).
[2] Ganley, O. H., and Robinson, H. J., *Fed. Proc.* (March 1959).
[3] Long, D. A., Miles, A. A., and Perry, W. L. M., *Lancet*, **ii**, 902 (1951).

ANATOMY

Function of the Fœtal Thyroid of the Rabbit with regard to Cholesterol Metabolism studied by Fœtal Thyroidectomy

In earlier communications, it was reported that the fœtal pituitary–thyroid system influenced cholesterol and fat metabolism. Following removal of this system, a significant rise in the serum cholesterol occurred[1], and also in the fat content of the fœtal liver[2]. The technique for removing the fœtal pituitary and thyroid involves decapitation of the fœtus either through the neck to remove both the thyroid as well as the pituitary, or through the mouth to preserve the thyroid. It has already been shown that this operation has no significant effect on the weight development of the fœtus[2–4], but it may be objected that the metabolic changes may be the result of removing structures other than the pituitary and the thyroid, such as the brain.

To overcome this objection and to investigate this problem further, the fœtal thyroid was removed

surgically on the twenty-second to twenty-third day of pregnancy and each operated foetus then allowed to continue development within the uterine cavity. These experimental foetuses with their litter mates for controls were recovered just before term on the twenty-ninth to thirtieth day of pregnancy by Cæsarian section. The serum cholesterol-levels were determined (as indicated in ref. 1) and the results are shown in Table 1.

Table 1. SERUM CHOLESTEROL IN THYROIDECTOMIZED AND CONTROL RABBIT FŒTUSES

Fœtuses	Age at investigation	No.	Mean serum cholesterol (mgm. / 100 ml. ± S.E.)
Thyroidectomized (at 22–23 days)	29–30 days	7	129* ± 7·7
Litter-mate controls	29–30 days	32	86* ± 3·5

* These differences are significant, $P < 0{\cdot}001$.

There is no significant difference in weight development of thyroidectomized and control fœtuses. The operated fœtuses all show a significant increase in serum cholesterol, and this indicates, therefore, that the fœtal thyroid plays a part in fœtal cholesterol metabolism. In addition, these results indicate that the maternal thyroid secretions are unable to compensate for the absence of the fœtal thyroid.

One of us (J. G. B.) expresses his indebtedness to Prof. A. Jost for his help in developing techniques for intra-uterine surgery of the fœtus, and to the Medical Research Council for a grant towards apparatus.

We are indebted to Prof. E. W. Walls and Prof. A. C. Dornhorst for their interest and guidance in this investigation.

J. G. BEARN
Department of Anatomy,
The Middlesex Hospital Medical School,
London, W.1.

H. B. KOERSELMAN
T. R. E. PILKINGTON
Medical Unit,
St. George's Hospital Medical School,
London, S.W.1.

[1] Bearn, J. G., Koerselman, H. B., and Pilkington, T. R. E., *Nature*, **189**, 318 (1961).
[2] Bearn, J. G., *Nature*, **185**, 849 (1960).
[3] Jost, A., *Cold Spring Harbor Symposia Quant. Biol.*, **19**, 167 (1954).
[4] Bearn, J. G., *C.R. Acad. Sci., Paris*, **250**, 198 (1960).

BIOLOGY

Transport of Carbon in Fungal Mycelium

INTEREST in the problem of translocation by fungi has been stimulated by Schütte's paper[1], and this communication is concerned chiefly with the movement of carbon compounds through an established mycelium.

We have investigated three aspects of translocation by fungi:

(1) Ability to grow from a 'complete' nutrient medium on to a 'deficient' medium (distilled water-agar) using the dish method of Schütte. Of 20 species representing all classes of the fungi, 10 were able to grow on to the deficient medium ('translocating' fungi *sensu* Schütte), 6 were unable to do so ('non-translocating' fungi) and 4 were indeterminate.

(2) The ability of growing mycelium to transport labelled carbon compounds using the dish technique with sucrose-^{14}C in the centre dish. All 'translocating' fungi were capable of moving compounds labelled with carbon-14 as the mycelium grew on to either deficient or complete media. However, 'non-translocating' species were also able to move labelled compounds when their mycelium grew out on to a complete medium; the possibility of respired $^{14}CO_2$ being re-absorbed by the growing mycelium was examined and rejected. This observation is at variance with Schütte's hypothesis that growth on to a deficient medium was evidence for translocation by a fungus.

(3) Movement of compounds labelled with carbon-14 through an established mycelium. Three species were used; two were selected as exemplifying the behaviour of 'translocating' fungi (*Rhizopus stolonifer* (Ehrenb. ex Fr.) Lind. and *Pellicularia filamentosa* (Pat.) Rogers) and one as a 'non-translocating' fungus (*Saprolegnia ferax* (Gruith.) Thuret) in the sense of Schütte.

The dish technique was used, there being a distance of approximately 4·6 cm. between the edge of the centrally placed, inner dish and the circumference of the outer dish. The complete medium, potato dextrose +0·1 per cent peptone, was chosen because it supported better growth of a wide range of fungi than any simple, synthetic medium; replication was achieved by using only a single batch of Oxoid dehydrated potato extract. The deficient medium was distilled-water agar containing Oxoid 'Ionagar No. 2'.

Complete liquid medium (approx. 15 ml.) was placed into the inner dish, and the outer dish poured with either deficient or complete agar medium. After inoculation of the inner dish and incubation at 25° C. for 14 or 16 days, some of the medium was withdrawn from the inner dish and replaced with 5-ml. fresh, complete liquid medium containing glucose-^{14}C having an activity of 5 μc. By this time the mycelium had usually completely covered the medium in the outer dish.

Incubation was continued, and at intervals the mycelium on the agar medium was sampled by cutting 3 disks (area 1 cm.^{2}) along a radius, the innermost close beside the central dish, the outermost at the circumference of the outer dish, and the third sample at a point midway between these two. The samples were counted and the results are presented in Table 1.

Some activity could be detected in the mycelium one hour after the glucose-^{14}C had been supplied. Thereafter, activity increased progressively at the innermost and central sampling sites up to about 78 hr., but there was little indication of accumulation at the outermost site, possibly because of more rapid catabolism in the physiologically younger part of the mycelium. The aerial mycelium of *R. stolonifer*

Table 1. MOVEMENT OF COMPOUNDS LABELLED WITH CARBON-14 THROUGH ESTABLISHED MYCELIUM

Elapsed time (hr.)	*P. filamentosa*						*R. stolonifer*						*S. ferax*		
	Deficient			Complete			Deficient			Complete			Complete		
	I	*M*	*O*	*I*	*M*	*O*	*I*	*M*	*O*	*I*	*M*	*O*	*I*	*M*	*O*
1	0	1	4	0	1	—	2	0	0	0	0	4	12	2	1
6	9	1	2	6	1	—	3	0	2	2	0	29	9	1	1
24	23	11	4				9	0	0				40	8	9
54	26	17	17	55	22	—	33	10	6	54	9	7	64	17	2
78	64	23	16	69	28	—				80	16	10	56	16	3
120							56	17	2				50	19	13

I, Innermost; *M*, middle; *O*, outermost sampling site; results expressed in counts/cm.^{2}/min. above background.

on the lid of the dish at the edge of the colony was also active.

Recently, Lucas[2] showed that compounds labelled with phosphorus-32 are not transported through an established mycelium, and suggested that their movement was normally concomitant with growth of the hyphal tips. Possibly a sink for carbon is maintained by respiration in the younger part of the mycelium, whereas a similar sink for phosphorus would not exist. Consequently, we do not consider our results are in conflict with those of Lucas, but that they reflect different metabolic patterns for carbon and phosphorus. However, when considered together, Lucas's results and our own are contrary to a 'mass flow' hypothesis of translocation in mycelium.

This work is being extended to include a study of the movement of phosphorus, and the forms in which carbon and phosphorus move in the mycelium.

Stella L. Thrower
L. B. Thrower

Botany School,
University of Melbourne.

[1] Schütte, K. H., *New Phyt.*, **55**, 164 (1956).
[2] Lucas, R. L., *Nature*, **188**, 763 (1960).

Prevention of Manganese Deficiency in Oat by soaking the Grain in Solutions of Manganous Chloride

Trace element deficiencies in crops are normally overcome by applying the required element to the soil or by spraying the plant with a solution containing it. However, it has been found that soaking seed in a solution of a salt of the required element is an effective way of preventing the development of deficiency symptoms in the crops grown from soaked seed[1-4]. Grey speck of oat, caused by manganese deficiency, is prevalent in many areas of west Scotland due usually to induced manganese deficiency associated with high soil *p*H. To our knowledge, the possibility of preventing this condition by seed soaking has not been reported before. The following investigations were carried out to determine the possible usefulness of such treatments.

The effects of different soaking treatments on the germination capacity of oat were determined. 5-gm. samples of oat grains (*Avena sativa* L. var. Victory) were soaked in 100 ml. of water or solutions of manganous chloride ranging in concentration from 0·2 per cent to 10·0 per cent w/v. After surface drying, the grains were germinated at 10° C. on moist filter paper in Petri dishes. With all soaking treatments longer than 36 hr., there were reductions in the rate of germination, and the final germination percentage. The magnitude of the effects was proportional to the concentration of the manganous chloride solution. With soaking periods less than 24 hr., and solutions less than 2 per cent manganous chloride, there was little adverse effect on germination.

The full requirement of manganese for a crop of oats has been reported to be 7 ounces per acre[5]. To meet this requirement, it is necessary for the grain to have a manganese content of 1,450 ngm. per lb. at the time of sowing, on the basis of an effective sowing-rate of 140 lb. per acre. The manganese content of the grains used in our experiments was 21·5 mgm./lb. In order to be successful there would need to be a considerable uptake of manganese during the soaking period, and at the same time, germination must not be affected adversely. An estimate of the amounts of manganese taken up during soaking was obtained by measuring the amount of manganese left in solution at the end of treatment using the colorimetric method of Sideris[6]. Some of the results obtained are given in Table 1.

Table 1

Length of soaking period (hr.)	Concentration of manganous chloride solution (percentage w/v)	Manganese content of grains (mgm./lb.)	Final germination (percentage)
0	0	21·5	100
8	2	1,290	94
24	2	2,290	91
24	10	5,920	15

From these figures it can be seen that the manganese content of the grain can be raised to a level which, without compromising germination, provides the full crop requirement. This was tested by growing plants from treated and untreated grain in nutrient solutions with and without manganese.

Twenty plants grown from grains treated by soaking in water or manganous chloride solution were supplied with modified Hoagland's solution[7] with or without manganese. Half of each sample was gathered after 63 days, and the remainder at maturity, after 114 days. The average dry weights of the plants are shown in Table 2.

Table 2

Length of soaking period	Soaking solution	Nutrient solution	Average dry weight (gm.) at 63 days	Average dry weight (gm.) at 114 days
24 hr.	distilled water	Complete	0·59	5·05
24 hr.	distilled water	manganese-free	0·26	3·27
8 hr.	2 per cent $MnCl_2$	manganese-free	0·40	4·99
24 hr.	2 per cent $MnCl_2$	manganese-free	0·73	4·41

Grey speck was observed on the control plants grown in manganese-free solutions before the 63-day stage, but was not observed at any time on any of the plants in the other treatments. The dry-weight figures bear out the contention that the method is a feasible way in which to provide the oat crop with its manganese requirement.

The possible use of seed-soaking treatments to overcome manganese deficiency under field conditions was investigated on a preliminary basis during 1959 using soil rich in shell sand from the Island of Tiree. Manganese-deficiency symptoms were not obvious in plants from treated grain, while plants from untreated grain showed typical grey speck and considerably reduced growth. Full-scale trials will be carried out this year and reported elsewhere.

Donald S. H. Drennan
Alex. M. M. Berrie

Department of Botany,
The University,
Glasgow, W.2

Gordon A. Armstrong

West of Scotland Agricultural
College,
County Advisory Service,
Tobermory, Mull.

[1] Novikov, V. A., and Sadovskaja, R. O., *C.R. Acad. Sci., U.R.S.S.*, **23**, 276 (1939).
[2] Donald, C. M., and Spencer, D., *Austral. J. Agric. Res.*, **2**, 295 (1951).
[3] Drozdov, S. N., *Herb. Abstr.*, 178 (1953).
[4] Silin, A. G., *Herb. Abstr.*, 170 (1953).
[5] Piper, C. S., and Walkley, A., *Austral. Counc. Sci. Indust. Res.*, **16**, 217 (1943).
[6] Sideris, C. P., *Indust. Eng. Chem.* (anal. ed.), **12**, 307 (1940).
[7] Went, F. W., *Experimental Control of Plant Growth*, 79 (Chronica Botanica, Waltham, Mass., 1957).

Nucleic Acids and Sexual Differentiation in *Allomyces*

THE finding that thymine is the most effective nucleic acid base in inducing proliferation of male gametangia in *Allomyces*[1] is of special significance for an understanding of the biochemical basis of sex differentiation in these water-moulds.

A first step towards understanding the nature of the thymine effect in *Allomyces* can be derived from recent demonstrations that this nitrogen base induces a selective, stimulatory effect on nuclear multiplication, with concomitant increase of the deoxyribonucleic/ribonucleic acid (DNA/RNA) ratio in the related mould *Blastocladiella*[2]. Consequently, we could expect a similar effect in *Allomyces* and safely predict that in promoting increased DNA synthesis relative to RNA (higher DNA/RNA ratios) in the cytoplasm of differentiating hyphæ, thymine automatically favours male differentiation, with its attributes of high rate of nuclear multiplication and low RNA basophily.

The gametophytic strains of *Allomyces* have been grown 8–10 days on Emerson's 'YpSs'[3] agar medium (Difco) in Petri dishes at 25° C. and the gametes collected by mild centrifugation 2–3 hr. after flooding the plates with Machlis's 'DS' solution[4]. Pellets of gametes were carefully washed twice with distilled water before their dispersal in 0·4 *N* potassium hydroxide for a 1 hr. extraction at 100° C. Two aliquots were then withdrawn and used according to McIntire and Sproull's[5] analytical procedure: (1) for selective DNA precipitation with salamine (protamine sulphate, supplied by Gen. Biochem. Inc., U.S.A.) 0·05 per cent at 4° C. overnight, followed by sodium chloride 10 per cent–sulphuric acid 0·1 *N* hydrolysis (30 min.) of the precipitate, previously washed with ice-cold distilled water; (2) for direct, sodium chloride 10 per cent–sulphuric acid 0·15 *N* hydrolysis at 100° C. (30 min.) to get the total purines and pyrimidines fraction. Measurements of both fractions at 268 and 330 mμ with a model *DU* Beckman spectrophotometer gave the basis for final calculations of the quantities of DNA and total purines and pyrimidines, using McIntire and Sproull's formulæ. RNA (ribonucleic acid) was considered as total purines and pyrimidines less DNA (negligible, soluble pool of purines and pyrimidines in the RNA nuclear cap-containing gametes of Allomyces). Proteins were determined with the biuret reaction[6].

As shown by my results summarized in Table 1, I have measured consistently a higher DNA/RNA ratio in the mixed populations of gametes liberated from the gametophyte of *Allomyces macrogynus* Emers. grown in the presence of additional thymine. Of importance is the fact that uracil, the corresponding RNA base, was ineffective in *Allomyces* as previously shown in *Blastocladiella*[2]. Such higher DNA/RNA ratios measured in the gametes of thymine-treated *Allomyces* conform to the expected higher proportion of male gametangia (minimal 75 per cent) differentiated under such conditions, and to the relatively smaller RNA nuclear caps[7] of the predominantly male gametes liberated. Incidentally, these determinations provide chemical confirmation of earlier microscopic data on the smaller value of the nuclear cap/nucleus volume ratio in the male compared to the female gametes in *Allomyces*[8]. Similar verification was obtained: (1) for the gametes of a male colchicine mutant[1] in comparison with the composite population of female and male gametes of the wild-type of *A. macrogynus*; (2) for the gametes of a male, hybrid strain (*A. macrogynus* × *A. arbuscula*[9]) compared with the gametes of a female, similar hybrid strain (Table 1).

Table 1

Cultures (8–10 days, at 25° C.)	♂/♀ gametangia	DNA/RNA* in gametes liberated
1. *Allomyces macrogynus* Emers.:		
Wild-type on 'YpSs' 'Difco' medium	1/1	9·6
Wild-type on peptone-glucose† ('PYG Cantino' 'Difco' medium)	1/2	8·4
Wild-type on 'YpSs' + thymine (2×10^{-3} *M*)	4/1	10·9
♂ Colchicine mutant on 'YpSs' medium	3/1	10·7
2. *A. macrogynus* × *A. arbuscula*:		
♀ hybrid strain	2/98	6·9
♂ hybrid strain	92/8	12·8

* Average values from three experiments.

† Feminizing medium.

Moreover, the higher proportion of DNA in the male gametes could also be verified on a protein basis:

male hybrid strain 12·0 μgm. DNA/mgm. protein
female hybrid strain 6·4 μgm. DNA/mgm. protein

The use of nucleic acid antagonists has tended to confirm the importance of the DNA/RNA balance in the biochemical basis for sex differentiation in *Allomyces*: at relatively high concentrations (10^{-2}–10^{-3} *M* in solid 'YpSs' 1/2 medium) all compounds favouring an increased DNA/RNA ratio in *Blastocladiella*[2]—that is, thiouracil, bromouracil, *iso*cytosine and (paradoxically) aminopterin—induced a significant increase in the male/female ratio (up to 75 per cent males on 10^{-2} *M* thiouracil) in *A. macrogynus*. Inversely, pteropterin, which tended to lower the ratio in *Blastocladiella*, showed a feminizing effect in *Allomyces*.

In conclusion, it appears as if differentiation of male sex organs in *Allomyces* is associated with the genetically controlled, polar accumulation of a biochemical system favouring more active DNA synthesis in the prospective male territory of the cytoplasm of differentiating hyphæ. Conversely, the prospective female territory is characterized by polar segregation, in this region of the cœnocytic cytoplasm, of a more 'vegetative' type of nucleic acid metabolism which favours RNA synthesis and—with its potential role in protein synthesis—confers on the future female gametes their well-known capability for parthenogenetic development.

I am indebted to Prof. Ralph Emerson, University of California at Berkeley, for his generous gift of the two hybrid strains of *Allomyces*. Thanks are also expressed to Prof. E. C. Cantino in whose Laboratory at Michigan State University, East Lansing, my first nucleic acid determinations were made.

G. TURIAN

Institute of General Botany,
University of Geneva.

[1] Turian, G., *Rev. Cytol. Biol. vég.*, **19**, 241 (1958).
[2] Turian, G., and Cantino, E. C., *J. Gen. Microbiol.*, **21**, 721 (1959).
[3] Emerson, R., *Lloydia*, **4**, 77 (1941).
[4] Machlis, L., *Amer. J. Bot.*, **40**, 189 (1953).
[5] McIntire, F. C., and Sproull, M. F., *Proc. Soc. Exp. Biol., N.Y.*, **95**, 485 (1957).
[6] Turian, G., *Path. Microbiol.*, **23**, 687 (1960).
[7] Turian, G., *C.R. Acad. Sci., Paris*, **240**, 2343 (1955).
[8] Turian, G., *Bull. Soc. Bot. suisse*, **67**, 458 (1957).
[9] Emerson, R., and Wilson, Ch. M., *Mycologia*, **46**, 393 (1954).

Determination of the Volume and Weight of Living Animals

When accurate measurements of the weight of aquatic animals are necessary, most authors remove the adherent water by towelling the body with filter paper and weigh quickly and repeat until a constant weight is obtained. The method is defective since, apart from possible damage to the animals, the degree of dryness reached may not be the same each time. These difficulties increase when the animals are small and several have to be used at a time. Similarly, determinations of volume necessitate an elaborate procedure or the use of complicated apparatus.

For small marine Crustacea I find the following procedure better than the volumometer which I described[1]. A basket is suspended by a nylon thread from one arm of a balance and immersed in a definite volume of sea-water in a beaker. The apparent weight of the basket and the thread is determined. The animals are then transferred to the basket and weighed. Next, a fourth of the sea water in the beaker is removed and distilled water is added, stirred and the animals weighed again. The animals are removed and the empty basket is weighed in the 75 per cent sea-water. The difference in apparent weights of the animals in sea-water of two densities will thus help to calculate the volume of sea-water displaced and also the weight in air.

It has been found that determinations of apparent weight are not vitiated by osmotic transport, since most Crustacea take more than 10 min. to respond to changes in media. This method is particularly suitable for making continuous observations on the rate of water transport in animals left in anisotonic media.

C. P. Gnanamuthu

Department of Zoology,
University of Madras,
India.

[1] Gnanamuthu, C. P., *Nature*, **170**, 587 (1952).

β-Galactosidase Changes in the Developing Intestinal Tract of the Rat

In some micro-organisms β-galactosidase (lactase) is an adaptive enzyme, that is, its biosynthesis is induced by external agents such as lactose or lactose-related substances[1]. Apparently this is not the case for the intestinal β-galactosidase of the rat, since a lactose-rich diet does not modify the intestinal specific activity[2]. In the work reported here, the behaviour of this enzyme has been investigated in the albino rat, starting from the last third of the intra-uterine life until adult age.

Homogenates of the small intestine from the duodenal flexure to the ileo-cæcal valve were used. The enzyme was determined by the *ortho*-nitrophenol released from the *ortho*-nitrophenyl-β-galactoside, at 38° C. and *p*H 3·5[4]. The age of fœtuses was estimated according to the histo-differentiation shown in the duodenal, ileo-cæcal and umbilical regions[3], independently of the biochemical values. This technique allows a very close correlation between histological and biochemical data.

The changes in β-galactosidase activity during the end of pregnancy, new-born period and adult age of the rat are plotted in Fig. 1.

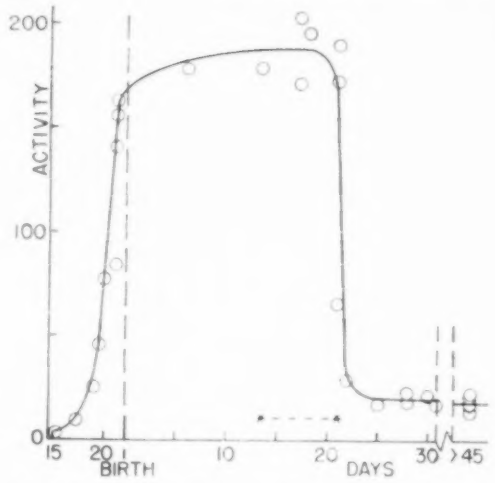


Fig. 1. Intestinal β-galactosidase activity expressed as mμmoles of *ortho*-nitrophenol released per mgm. of tissue (wet weight) in 1 hr. * - - - - * Transition from lactation to adult diet; gestation, 22 days

The enzyme activity was also examined in different physiological and dietetic conditions: in adults on a lactose-rich diet, in pregnant rats, in nursing mothers, and in young rats kept after weaning on a complete diet with lactose (25–30 per cent) as the only carbohydrate (lactose-rich diet). The results are recorded in Table 1 together with the values for the normal adult and suckling rats.

Table 1. Intestinal β-galactosidase Activity expressed as mμmoles *ortho*-nitrophenol released per mgm. of Tissue (Wet Weight) per 1 Hr.

Diet	Condition	No. of animals	β-galactosidase activity	Increase
Normal	Adult	5	18 ± 2·9	× 1·00
Normal	Pregnant	4	18·6 ± 1·0	× 1·03
Normal	Nursing	3	18·4 ± 2·4	× 1·02
Mother's milk	1–20 days old	14	183 ± 8·8	× 10·0
Lactose*	Adult	3	19·3 ± 2·1	× 1·07
Lactose	25–27 days old	3	19·8 ± 3·0	× 1·10

* 'Lactose' means a complete diet with lactose 25–30 per cent as the only carbohydrate.

The features which became apparent from these results are: (1) The specific activity does not change on the diet rich in lactose (no induction in a strict sense), confirming discoveries of other authors[2]. (2) There are no significant changes either in the pregnancy or in the nursing period. (3) Activity increases rapidly at the end of fœtal life until birth, parallel to the very fast histo-differentiation of the digestive tract[3]. The high level remains rather constant in the new-born. (4) At the time of weaning (21–22 days) the activity decreases abruptly to the low adult-value. (5) This net decrease in the activity also occurs when the new-born is kept on the lactose-rich diet.

Several authors have shown that lactose hydrolysis is necessarily previous to its intestinal absorption; the somewhat low β-galactosidase adult activity makes its action a limiting step in lactose assimilation, and therefore laxation and diarrhœa occur[2]. An activity ten times higher in the new-born, as compared with the adult animal, is in agreement with the expected great efficiency as regards milk lactose assimilation in the sucklings. The 'physiological

immaturity of the new-born' seems to be in this case rather a physiological adaptation (in a broad sense) to a milk diet. In any event, β-galactosidase belongs to the few biochemical systems showing an activity in this period, generally marked by enzyme deficiencies[5], higher than in adult age.

Conchie *et al.*[6] have shown a considerable increase for this and other mammalian glycosidases in the epididymis, apparently associated with sexual development. The enzyme activity from other tissues remains about the same during and after growth, and this finding has been confirmed by us for the pancreas and liver in all the conditions mentioned here.

It should be noted that the fall in β-galactosidase activity is observed at the time of weaning, where other authors have found a loss of permeability to macromolecules, such as insulin and anticorps[6]. This age seems to be peculiar in the evolution of the gastro-intestinal tract of the rat.

This work was supported by the Rockefeller Foundation.

ANIBAL ALVAREZ
JOSÉ SAS

Departamento de Bioquímica y
Departamento de Neurobiología,
Instituto de Investigación de
Ciencias Biológicas,
Avda. Italia 3318
Montevideo, Uruguay.

[1] Monod, J., Cohen-Bazire, G., and Cohn, M., *Biochim. Biophys. Acta* **7**, 585 (1951).
[2] Fischer, J. E., *Amer. J. Physiol.*, **188**, 49 (1957); *J. Dairy Sci.*, **36**, 7 (1953).
[3] Kammeraad, A., *J. Morphol.*, **70**, 323 (1942).
[4] Conchie, J., Findlay, J., and Levvy, G. A., *Biochem. J.*, **71**, 318 (1959).
[5] Driscoll, S. G., and Hsia, D. Y., *Pediatrics*, **22**, 785 (1958).
[6] Mosinger, B., Placer, Z., and Koldorský, O., *Nature*, **184**, 1245 (1960). Halliday, R., *J. Endocrinol.*, **18**, 52 (1959).

Avian Schistosomes in Hertfordshire

Limnaea stagnalis collected from three sources in the vicinity of Winches Farm Field Station of the London School of Hygiene and Tropical Medicine were found to be shedding furcocercous cercariæ. On emergence from the snail, the cercariæ swam freely for a short time with either the head- or tail-end forward and then attached themselves to the side of a beaker nearest the light. The cercariæ were apharyngeal, possessed a pair of eyespots and had six pairs of flame cells in the body and one pair at the base of the tail. The posterior part of the body was taken up by five pairs of penetration glands, the two anterior pairs having coarsely granular and the three posterior pairs having finely granular contents. In its behaviour and morphological characters the cercaria is identical with that described as *C. ocellata* by Rees[1] and Taylor and Bayliss[2], who have given a detailed description of the cercaria which will not be repeated here. At one site (Verulamium Lake) a small percentage of *Limnaea ovata* were occasionally found to be shedding this cercaria. In both hosts the sporocysts were located in the digestive gland.

Several attempts were made to infect domestic ducks, by single and multiple infections, by cutaneous and oral routes with pooled cercariæ from a large number of infected snails. Droppings were examined for eggs at weekly intervals, and at 4–6 months post-mortem examinations for worms were made. All results were negative. It has been observed that the birds common to all three locations are duck, moorhen and coot.

D. L. H. ROBINSON

Bilharzia Research Unit,
Medical Research Council,
Winches Farm,
St. Albans, Herts.

[1] Rees, F. G., *Proc. Zool. Soc. Lond.*, **1**, 1 (1932).
[2] Taylor, E. L., and Bayliss, H. A., *Trans. Roy. Soc. Trop. Med. and Hyg.*, **24**, 2, 219 (1930).

Diapause, Neurosecretion and Hormones in Copepoda

DESPITE the great advances made during the past decade in the investigation of the endocrinology of the Crustacea Malacostraca[1], little or nothing has been published on the endocrine organs or hormones of the lower Crustacea. Neurosecretory cells have been observed in barnacles[2], but nothing is known for certain of any hormonal emanations from these cells.

Calanus finmarchicus and *C. helgolandicus* pass through three generations a year, in southern populations at least, overwintering as the last larval instar (the fifth copepodid stage)[3]. It has recently been shown (Smyly, W. J. P., personal communication) that *Cyclops leuckarti* has a similar life-history, and that, in this species, the overwintering copepodid penetrates to a depth of some 15 cm. into the mud of lake bottoms, passing the cold season in a quiescent state. This condition has obvious analogies with the diapause of many species of insects, which is known to be controlled by the endocrine system, especially by the neurosecretory system of the brain. We have therefore embarked on an investigation of the equivalent system of copepods.

The endocrine structures of the cerebral region of *Calanus* include a pair of lateral groups of neurosecretory cells at the front edge of the brain. From these the neurosecretory fibres pass forward and outward, skirting round the anterior blood sinus to reach the frontal organ. In adult and juvenile copepodids taken during the summer months these neurosecretory cells contain an abundant granular secretion. In the overwintering larvæ, however, this secretion is grossly depleted or even absent. By analogy with insects, therefore, we conclude that the secretion of these cells is probably playing some part in the control of the diapause, moulting and the overwintering metabolism and behaviour.

In the Crustacea Decapoda the same endocrine structures which are concerned with the control of moulting and metabolism also govern colour change. It therefore seemed reasonable to look for chromactivating hormones in copepods, even though they may possess no chromatophores. Accordingly, extracts of whole *Calanus finmarchicus* and of whole *Euchaeta norvegica* were assayed for chromactivating substance *A* (ref. 4) on *Leander adspersus*. One unit of this substance was found in 7·2 whole *Calanus*, while 6·5 units were found in one whole *Euchaeta*. The whole of the activity was found to be present in the cerebral region of the body in *Euchaeta*, and in the brain plus frontal organ of *Calanus*. It seems likely, therefore, that this hormone is secreted, as in decapods, by the neurosecretory cells of the brain.

This work is continuing, and a fuller account will be published elsewhere. We are grateful to Dr. F. S. Russell, Dr. S. M. Marshall, Mr. W. J. P. Smyly, Dr. B. Swedmark, the National Science Foundation and

the Browne Fund of the Royal Society for the various ways in which they have helped advance this investigation.

D. B. Carlisle

Marine Biological Association,
Plymouth.

W. J. Pitman

Ohio State University, Columbus, Ohio,
and the
Laboratory of the Marine Biological Association,
Plymouth.

[1] Carlisle, D. B., and Knowles, F. G. W., *Endocrine Control in Crustaceans* (Camb. Univ. Press, 1959).
[2] Barnes, F., and Gonor, J. J., *Nature*, **181**, 194 (1958).
[3] Russell, F. S., *J. Mar. Biol. Assoc. U.K.*, **15**, 429 (1928). Marshall, S. M., and Orr, A. P., *The Biology of a Marine Copepod* (Edinburgh, 1955).
[4] Knowles, F. G. W., Carlisle, D. B., and Dupont-Raabe, M., *J. Mar. Biol. Assoc. U.K.*, **34**, 611 (1955).

Verification of the Gastropod Golgi Cycle with an Electron Microscope

The Golgi cycle of the gastropod (*Navanax*) was detailed[1], based on osmicated preparations and studies of living embryos vitally stained with methylene blue. However, because of the scepticism that has surrounded vital-dye observations, particularly since the neutral red controversy of the early 'thirties, these studies with methylene blue have never enjoyed complete acceptance by cytologists and have been severely criticized in some quarters.

It is particularly important, therefore, to report that our recent investigations of gastropod (*Crepidula*) development, by means of the ultra-thin sectioning technique, confirm substantially the earlier findings with methylene blue. Taken together, these two independent approaches to the Golgi body problem offer what we consider to be strong evidence that :

(1) The Golgi 'apparatus' in the gastropod veliger exhibits a cycle in which certain stages can be identified consistently by both methods; these stages are Golgi granules (droplets), simple vesicular Golgi bodies (Fig. 1, *SVG*); compound vesicular Golgi bodies, pycnotic Golgi bodies (*PG*), as well as disintegrating plates of primary yolk and newly formed mature secondary yolk spheres (*MY*).

(2) The Golgi system engages in the elaboration of protein yolk which makes its initial appearance as the chromophobic component of the Golgi body, increases greatly in size during the embryonic stages, and is eventually released as a mature yolk plate by virtue of the withdrawal from its surface of the chromophilic Golgi envelope (Fig. 1, *GW*).

(3) The Golgi complement of these cells is a series of spheres, presumably chiefly phospholipoidal in chemical composition[2], but such phospholipid spheres, through their ability to release their cores as formed cell products, play a dynamic part in the economy of the cell.

(4) Under appropriate control the microscopically visible chromophilic components of the Golgi elements in these living cells are selectively stained by methylene blue and are thus revealed in essentially unaltered form comparable with identical stages observed by means of the electron microscope.

These observations, which will be reported in detail elsewhere, indicate that in these, and perhaps in many animal cells, the function of the Golgi 'apparatus' is the continual building up of formed energy reserves from the raw nutritive materials present in the cytoplasm.

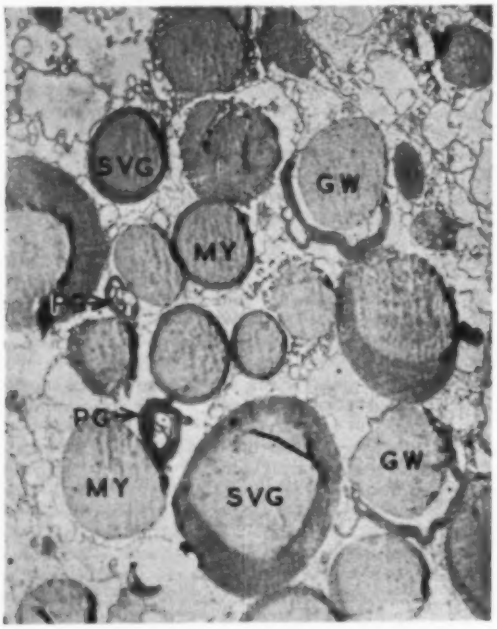


Fig. 1. Electron micrograph (× 3,400) of yolk-laden cell of *Crepidula veliger* showing three stages in the elaboration of protein yolk. Simple vesicular Golgi bodies (*SVG*), consisting of chromophilic cortices and chromophobic centres, eventually release the latter (*GW*) as mature secondary yolk spheres (*MY*). Following this withdrawal of the chromophilic envelope (*GW*), the Golgi material lies temporarily at the side of the yolk sphere as a hollow, pycnotic Golgi remnant

Leonard G. Worley
Betty Hershenov

Biological Laboratories,
Brooklyn College,
New York.

[1] Worley, L. G., and Worley, E. K., *J. Morph.*, **73**, 365 (1943).
[2] Baker, J. R., *Quart. J. Micro. Sci.*, **85**, 1 (1944).

A 'Natriferic' Principle other than Arginine–Vasotocin in the Frog Neurohypophysis

It has been shown that neurohypophyseal extracts from amphibians and teleosts stimulate the active sodium transport across frog skin more markedly than do extracts from mammalian pituitaries, and this led to the hypothesis that they contain a new hormone, differing from either oxytocin or vasopressin[1,2]. Its chemical constitution being unknown, this principle has been provisionally called 'natriferin'. Its possible identity with Heller's 'water-balance principle'[3] was of interest.

A synthetic peptide, arginine–vasotocin, prepared by Katsoyannis and du Vigneaud[4], has been shown to possess the pharmacological properties ascribed to the 'water-balance principle'[5,6], and to exhibit a high natriferic activity[7,8]. Moreover, a hormone having the same amino-acid composition and the same pharmacological properties as arginine–vasotocin has been extracted from the neurohypophysis of the chicken[9], the frog[10], and a teleostean[11].

According to Sawyer[7], the natriferic activity of the frog neurohypophysis should be entirely attributed to arginine–vasotocin. The results described below, however, indicate that arginine–vasotocin accounts only for approximately one-half of the total natriferic activity of the neurohypophysis of the frog, *Rana esculenta*. The remaining half must be ascribed to an active principle, differing from either oxytocin or arginine–vasotocin and of as yet unknown chemical constitution; this principle has not been found in the chicken.

The neurohypophyseal hormones of the frog, *Rana esculenta*, were purified by a method described previously[5,9,10,12], and treated by means of a gradient elution technique with an 'Amberlite *IRC*–50' column[12]. Fig. 1 shows the chromatographic profile obtained for the oxytocic activity (tested on the rat uterus) and the natriferic activity (tested on the 'short-circuited' frog skin[1]) of the eluate fractions. Natriferic activity was tested using synthetic oxytocin ('Syntocinon', Sandoz) as a standard. By definition, one natriferic unit corresponds to the effect produced by one I.U. of oxytocin. The complete analysis was carried out three times with separate batches of glands and comparable profiles were obtained.

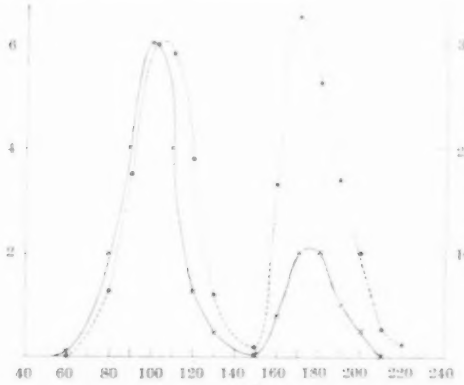


Fig. 1. Chromatographic profile of the frog neurohypophyseal principles. The hormones are separated on 'Amberlite *IRC*-50' by a gradient (of *p*H and ionic strength) elution technique (ref. 12). Concentrations and *p*H of the ammonium acetate buffer are shown below the figure. The oxytocic (left-hand scale) and natriferic (right-hand scale) activities of the effluent fractions are expressed in units/ml. Note that different scales are used. The right-hand natriferic peak corresponds to arginine–vasotocin and the left-hand natriferic peak to an unknown principle
×, Oxytocic activity; ●, natriferic activity

A study of the effluent fractions corresponding to the right-hand side of the chromatographic profile reveals coincident peaks of oxytocic and natriferic activities (25 per cent and 50 per cent of the total recovered activities respectively), corresponding to a substance which exhibits also a strong vasopressin activity[10]. This substance has the same amino-acid constitution and the same pharmacological properties as arginine–vasotocin[10], which is also present in the chicken neurohypophysis[9].

The left-hand side of the profile shows other peaks of oxytocic and natriferic activities (75 per cent and 50 per cent of the recovered activities, respectively). The peak of natriferic activity must necessarily be attributed to an unknown principle for the following reasons: (1) The strong natriferic activity as compared with the oxytocic activity (3–15 times higher, according to the region of the peak), eliminates the possibility that this substance is oxytocin, although oxytocin appears as a rule in this region of the chromatogram. (2) Its position on the profile and the absence of associated vasopressic activity[10] distinguish it from arginine–vasotocin. (3) The 'water-balance' activity of the pooled effluent fractions number 110–130, determined by means of Sawyer's gravimetric technique[6] on *Rana esculenta* bladder, was found to be ninety times higher than oxytocin itself and about 2·5 times less active than arginine–vasotocin. (4) The pooled effluent fractions, number 110–130, have no antidiuretic activity in both the rat and the frog. This contrasts with the high antidiuretic activity exhibited by arginine–vasotocin[8].

In the chicken, however, the effluent fractions corresponding to the left-hand side of the profile show only a low peak of natriferic activity coincident and equivalent to the peak of oxytocic activity. Oxytocin has been characterized chemically in this region of the chromatogram[12]; its presence accounts entirely for the observed natriferic activity.

F. Morel
J. Maetz

Département de Biologie,
Commissariat a l'Énergie Atomique,
Saclay.

R. Acher
J. Chauvet
M. T. Lenci

Laboratoire de Chimie biologique,
Faculté des Sciences,
Paris.

[1] Maetz, J., Morel, F., and Race, B., *Biochim. Biophys. Acta*, **36**, 317 (1959).
[2] Maetz, J., Morel, F., and Lahlouh, B., *Nature*, **184**, 1236 (1959).
[3] Heller, H., *J. Physiol.*, **100**, 125 (1941).
[4] Katsoyannis, P. G., and du Vigneaud, V., *J. Biol. Chem.*, **233**, 1352 (1958).
[5] Sawyer, W. H., Munsick, R. A., and van Dyke, H. B., *Nature*, **184**, 1464 (1959).
[6] Sawyer, W. H., *Endocrinol.*, **66**, 112 (1960).
[7] Sawyer, W. H., *Nature*, **187**, 1030 (1960).
[8] Jard, S., Maetz, J., and Morel, F., *C.R. Acad. Sci., Paris*, **251**, 788 (1960).
[9] Chauvet, J., Lenci, M. T., and Acher, R., *Biochim. Biophys. Acta*, **38**, 571 (1960).
[10] Acher, R., Chauvet, J., Lenci, M. T., Morel, F., and Maetz, J., *Biochim. Biophys. Acta*, **42**, 379 (1960).
[11] Heller, H., and Pickering, B. T., *J. Physiol.*, **152**, 56*P* (1960).
[12] Acher, R., Chauvet, J., and Lenci, M. T., *Biochim. Biophys. Acta*, **38**, 344 (1960).

Enhancement of Intraperitoneal Staphylococcal Virulence for Mice with Different Bile Salts

The intraperitoneal injection of a 1 per cent mixture of equal parts of sodium taurocholate and sodium glycocholate followed by an inoculum of *Staphylococcus aureus* has been previously found to enhance virulence of the latter for mice[1]. In the light of this observation, effectiveness in this respect of other individual bile salts, as well as the minimal effective concentration of those salts possessing such activity, was investigated.

Sodium taurocholate, sodium glycocholate, sodium glycotaurocholate and sodium dehydrocholate were obtained from Nutritional Biochemicals Co., sodium cholate from K. and K. Laboratories and sodium deoxycholate from the Fisher Scientific Co. All were

readily soluble in distilled water and were sterilized by autoclaving at 15 lb. for 15 min. 0·5 ml. of the indicated concentration of each bile salt was injected intraperitoneally into groups of 10 albino, male Swiss mice weighing 15–20 gm., followed immediately by 0·3 ml. of an 18-hr. culture of a strain of *Staphylococcus aureus* grown in trypticase soy broth at 37° C. The latter had been isolated from a purulent lesion and was highly pigmented, haemolytic, coagulase-positive, and fermented mannitol. All deaths occurring within 48 hr. as well as the number of positive post-mortem heart-blood cultures for *Staphylococcus aureus* in the animals that died were noted. In addition, one group of 10 mice received 0·5 ml. of 5 per cent gastric mucin and another group of 10, 0·5 ml. of physiological saline immediately prior to the intraperitoneal bacterial injection, as controls. A mortality of 10 out of 10 deaths within 48 hr. with 10 positive post-mortem heart-blood cultures was produced with the gastric mucin adjuvant whereas there were no fatalities with the saline solution. Intraperitoneal toxicity of 0·5 ml. of different concentrations of each bile salt *per se* was also determined. Sodium deoxycholate, 0·25 per cent, elicited a mortality of 3/10 with all post-mortem heart-blood cultures negative; 0·1 per cent was innocuous. 4 per cent was found to be the maximum non-lethal concentration of sodium dehydrocholate. No fatalities occurred with a 1 per cent concentration of the remaining bile salts.

The number of fatal bacteræmias produced by the intraperitoneal staphylococcal inoculum with the aid of different concentrations of each bile salt investigated is contained in Table 1. As may be observed from Table 1, complete to almost complete mortality accompanied by bacteræmia was obtained with 0·25 per cent sodium deoxycholate and with a 1 per cent concentration of the remaining bile salts tested except sodium dehydrocholate. Lesser concentrations produced lower mortalities. The same intraperitoneal bacterial inoculum without bile salts, on the other hand, had resulted in no deaths. The maximal tolerated concentration of sodium dehydrocholate, 4 per cent, failed to elicit any mortality. Since the failure of the latter might conceivably have been due to a bactericidal activity on its part against the injected *Staphylococci*, the following experiment was performed. 0·3 ml. of an overnight culture of the test strain was distributed into each of two series of tubes. 0·5 ml. of 4 per cent sodium dehydrocholate was added to the tubes of one series, 0·5 ml. of physiological saline to the other. All were placed in a shaker water bath at 37° C., oscillating at approximately 120 per minute and comparative colony counts upon similar aliquots from both series at intervals of 2, 4, 6, 8 and 24 hr. were performed. No significant reduction in the number of viable bacteria was observed following exposure to sodium dehydrocholate as compared with physiological saline even up to 24 hr., so that the ineffectiveness of sodium dehydrocholate as a virulence-enhancing substance could not be attributed to any sterilizing effect upon the bacterial inoculum in the peritoneum.

Table 1. Mouse Mortality/10 and Positive Post-Mortem Heart Blood Cultures elicited by Intraperitoneally Injected *Staphylococcus aureus* with the Aid of Various Concentrations of Different Bile Salts
(Mortality with 5 per cent gastric mucin—10 (10); with physiological saline—0)

Bile salt	Concentration of bile salts					
	4 per cent	1·0 per cent	0·5 per cent	0·25 per cent	0·1 per cent	0·05 per cent
Sodium taurocholate		10 (10)*	0	0	0	
Sodium glycocholate		8 (8)	4 (4)	1 (0)	0	
Sodium glycotaurocholate		10 (10)	6 (6)	2 (2)	0	
Sodium cholate		10 (9)	3 (3)	3 (3)	0	
Sodium deoxycholate				10 (10)	7 (5)	1 (1)
Sodium dehydrocholate	0	0				

* No. of post-mortem heart-blood cultures positive for *Staphylococcus aureus*.

Many chemically diverse substances, including certain anionic and non-ionic surfactants, have been found capable of converting ordinarily innocuous intraperitoneal staphylococcal infections in mice into rapidly fatal ones associated with septicæmia[1,2]. All possess one property in common, namely, the ability to lower surface tension. A substance possessing this characteristic might conceivably interfere with contact between peritoneal phagocytes and the bacteria so that the former are no longer able to envelop, engulf and destroy the latter. Furthermore, permeability of the peritoneal barrier between the abdominal cavity and the blood might also be increased by the surfactant and thus facilitate passage of the intraperitoneal organisms directly into the blood stream, thereby permitting them to circumvent the protective action of peritoneal phagocytes and minimize their exposure to the bactericidal action of peritoneal fluid. The surface tension-lowering ability of each bile salt was determined by means of the capillary tube method[3], with the following results: values expressed in dynes/cm. at 25° C. for physiological saline was found to be 66·2; that of 1 per cent sodium taurocholate, sodium glycocholate, sodium glycotaurocholate and sodium cholate 41·6, 40·4, 38·0 and 45·3 respectively; of sodium deoxycholate 0·25 per cent, 45·3; while that of 4 per cent sodium dehydrocholate was 61·3. The lack of effectiveness of the last bile salt provides additional evidence to indicate that an association exists between the ability of a substance to lower surface tension and its ability to enhance virulence of intraperitoneally injected *Staphylococci* for mice.

This investigation was supported by Research Grant No. *E*–2687 of the U.S. Public Health Service, National Institutes of Health.

S. Stanley Schneierson
Daniel Amsterdam
Ely Perlman

Department of Microbiology,
Mount Sinai Hospital,
New York.

[1] Amsterdam, D., and Schneierson, S. S., *Proc. Soc. Exp. Biol. and Med.*, **101**, 396 (1959).
[2] Amsterdam, D., and Schneierson, S. S., *Nature*, **186**, 101 (1960).
[3] Findlay, A., *Practical Physical Chemistry*, fourth ed., 74.

Paper Chromatography of Natural Saponins

Apart from an early attempt by other authors[1–3] to adapt a method of paper chromatography for the examination of natural saponins, the potentialities in this field do not seem to have been investigated. The present communication deals with the application of paper partition chromatography to the identification

new

from the **BUSH** laboratories

Guaiacol Phenylacetate
*
Heliotropine Sodium Bisulphite
Piperonyl Alcohol * Piperonylic Acid
Anisic Acid * Benzhydrol
3:5-Dichlorosalicylaldehyde
*
N:N'-Disalicylidenepropylenediamine
*
Ethyl Benzoylacetate
*

BUSH

W. J. BUSH & CO LTD · LONDON E.8 · ENGLAND
CLISSOLD 1234

ACADEMIC PRESS New York and London

CROSSED-FIELD MICROWAVE DEVICES

Editor in Chief: E. OKRESS, *Sperry Gyroscope Company, Great Neck, New York*
Editors: G. MOURIER, *Centre d'Etudes Physiques Electroniques et Corpusculaires Compagnie Générale de Télégraphie Sans Fil, Orsay, France*
E. KETTLEWELL, *General Electric Co. Ltd., First Way, Wembley, England*
J. FEINSTEIN, *S-F-D Laboratories, Inc., Union, New Jersey*
Assistant Editor: G. R. FEASTER, *Westinghouse Electric Corporation, Elmira, New York*

These two volumes fill an important gap in the literature by summarizing the progress and state of the art of crossed-field microwave devices in theory and practice. In order to indicate not only established uses but also possible future applications, the authors have included thorough surveys of the available literature. Their primary objective has been to enable students and professional physicists and engineers to understand the fundamentals of all existing important types of crossed-field devices, to perceive the problems posed by each element of the devices in practice and in theory, to know the essentials of the means available for solving these problems, and to develop approaches to the design of other devices. There is no other work which covers the subject so completely.

VOLUME 1 *June* 1961, 648 *pp.*, 157*s.*
Principal Elements of Crossed-Field Devices

VOLUME 2 *June* 1961, 520 *pp.*, *approx.* 120*s.*
Principal Types of Crossed-Field Devices
Analysis of Oscillator System Performance
Regional Progress and Trends

Advances in ELECTRONICS AND ELECTRON PHYSICS

Edited by L. MARTON, *National Bureau of Standards, Washington, D.C.*

VOLUME 14 *April* 1961, 341 *pp.*, 88*s.*

The Electron as a Chemical Entity
By C. G. B. GARRETT
Problems of Photoconductivity
By P. GÖRLICH
Strong-Focusing Lenses
By ALBERT SEPTIER
Hydrogen Thyratrons
By SEYMOUR GOLDBERG *and* JEROME ROTHSTEIN
Cerenkov Radiation at Microwave Frequencies
By HERBERT LASHINSKY
High-Power Axial-Beam Tubes
By T. MORENO

AUTHOR INDEX—SUBJECT INDEX.

Reviews of Previously Published Volumes:

"The book covers an area of extreme interest and importance, not least in the military field and should certainly find a place in many technical libraries. The individual research worker could find much of detailed value in the volume. . . ."
—*British Communications and Electronics*

"The extension of this series into electronics is particularly evident in these volumes, since many modern electronic techniques are discussed. These books will serve as an excellent source of review material for the subjects covered."
—*IRE Transactions of Electron Devices*

Phone: WHItehall 6631

111 FIFTH AVENUE, NEW YORK 3 17 OLD QUEEN STREET, LONDON, S.W. 1

of natural saponins and the separation of the constituents present, with particular reference to saponins of the important medical plants.

Such a separation was found to be readily achieved using the system *n*-butanol/acetic acid/water (6 : 1 : 3) as mobile phase. Good separation requires a 3-hr. conditioning of the Whatman No. 1 filter paper strip with substances applied in the chromatograph chamber, saturated with vapour of the solvent (the walls are lined with the paper). About 0·2 mgm. of the saponin dissolved in 50 per cent ethanol (primulic acid in 95·5 per cent ethanol) is spotted at the origin, and an ascending chromatogram is run at 19–20°. The solvent front moves slowly, usually about 30 cm. in 15–18 hr.

The strips are then exposed to a stream of warm air for 5 min. After evaporation of excess acetic acid, the chromatograms are heated at 105° for a further 30 min.

The detection reagent which yielded the best results was a 25 per cent ethanolic solution of phosphotungstic acid[4,5]. Other solvent systems and reagents are being tested. Characteristic colours reach optimum intensity in about 2 min., by which time very little background colour has developed. Each of the saponins examined so far yields a characteristic chromatogram distinguishable by the number, colour and R_F values of the coloured zones.

The colours obtained are: blue in daylight and ultra-violet light with *Herniarias glabra* saponosides; blue in daylight and pink in ultra-violet light with saponosides of *Saponaria officinalis* L. and *Gypsophila paniculata* Fisch. (Caryophyllaceae); magenta with primulic acid; cherry-red with the saponosides of *Calendula officinalis* L. (Compositae); violet with saponosides of *Polygala senega* L. (Polygalaceae); grey-green with escinol from *Aesculus hippocastanum* L. (Hippocastanaceae) and saponosides of *Quillaja Saponaria molina* (Rosaceae). The saponosides yield spots of the same colours as their aglycones when treated with phosphotungstic acid[4–6].

Full details will be published in *Dissertationes Pharmaceuticae*, Cracow, Poland (in English).

B. Pasich

Department of Pharmacognosy,
Medical Academy,
Poznań.

[1] Belic, I., *Nature*, **178**, 538 (1956).
[2] Coulson, C. B., *J. Sci. Food Agric.*, **9**, 281 (1958).
[3] Van Atta, G. R., and Guggolz, J., *J. Agric. Food Chem.*, **6**, 849 (1958).
[4] Pasich, B., *Nature*, **181**, 765 (1958).
[5] Pasich, B., *Dissert. Pharm.*, **11**, 31 (1959).
[6] Pasich, B., *Dissert. Pharm.*, **12** (in the press).

MICROBIOLOGY

A Diurnal Cycle for Holotrich Protozoa of the Rumen

In the last decade the study of the ciliate protozoa of the rumen has emphasized the investigation of individual species, rather than the ciliate population as a whole.

Several outstanding biochemical differences between Oligotrichs and Holotrichs have now been established *in vitro*[2–4]. However, *in vitro* work can delineate biochemical capabilities only. It cannot predict with certainty the activity of these organisms *in vivo*, and therefore if any attempt were made to estimate the value of the organism of the host animal, some knowledge of the ecological factors concerned is necessary.

Initial investigations into factors affecting the concentration of protozoa *in vivo*[5] have demonstrated a diurnal cycle for *Entodinium*. This cycle is in agreement with that obtained by other workers[6,7]. In the work described here a diurnal cycle for the holotrich protozoa was demonstrated.

Two merino wethers, fitted with rumen fistulæ, were fed a ration consisting of 560 gm. oaten chaff and 150 gm. lucerne chaff daily at 0900 hr. After 25 days on this ration, rumen samples were taken at 0, 1, 2, 3, 4, 6, 8, 10, 12, 16 and 20 hr. after feeding for 3 consecutive days. Samples were taken from the bottom of the rumen, and protozoal counts were made by the method described by Purser and Moir[5]. The holotrich species consisted entirely of *Dasytricha*.

Variations between sheep and between days were not significant, but statistical analysis revealed the highly significant ($P < 0{\cdot}001$) regression $y = 2132{\cdot}8 - 192{\cdot}3x + 5{\cdot}1x^2$ between holotrich concentration (y) and the time in hours after feeding (x). This curve and the mean values are presented in Fig. 1.

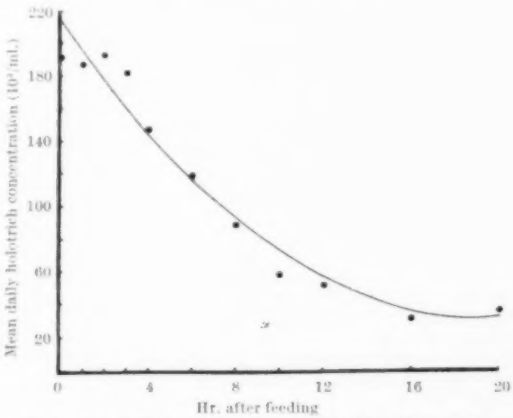


Fig. 1. Mean daily holotrich concentration (●) and the regression $y = 2132{\cdot}8 - 192{\cdot}3x + 5{\cdot}1x^2$ ($P < 0{\cdot}001$) between holotrich concentration (y) and the time in hours after feeding (x)

This diurnal cycle differs substantially from that exhibited by *Entodinium*. Whereas the concentration of holotrichs diminishes gradually until 20 hr. after feeding and then builds up rapidly to the original concentration, the recovery of *Entodinium* begins only 8 hr. after feeding. It has been suggested that the *Entodinium* cycle is controlled largely by physical dilution factors such as those due to feeding and salivation[5]. This would not appear to be the case for the holotrichs.

It is possible that the holotrich cycle is a reflexion of site differences for the cycle implies a five-fold increase in the concentration in 4 hr. Boyne *et al.*[8], however, have failed to demonstrate a site difference and it is difficult to understand why a sudden change in site distribution should occur immediately before feeding.

This cycle has been confirmed afterwards in experiments under different nutritional régimes, but the factors governing it have not been explained. It is important, however, that this difference between holotrichs and oligotrichs *in vivo* is recognized, when

samples are taken from animals for population analysis or for *in vitro* work.

D. B. Purser

Institute of Agriculture,
University of Western Australia,
Nedlands.

[1] Oxford, A. E., *Exp. Parasitol.*, **4**, 569 (1955).
[2] Masson, F. M., and Oxford, A. E., *J. Gen. Microbiol.*, **5**, 664 (1951).
[3] Sugden, B., *J. Gen. Microbiol.*, **9**, 44 (1953).
[4] Sugden, B., and Oxford, A. E., *J. Gen. Microbiol.*, **7**, 145 (1952).
[5] Purser, D. B., and Moir, R. J., *Austral. J. Agric. Res.*, **10**, 555 (1959).
[6] McDougall, E. M. (private communication).
[7] Nottle, M. C., M.Sc. thesis, University of Western Australia (1956).
[8] Boyne, A. W., Eadie, J. M., and Raitt, K., *J. Gen. Microbiol.*, **17**, 414 (1957).

Multiplication of Hansen's Bacillus in Complex Symbiosis *in vitro*

The work reported here followed a chance observation made while attempting, without success, to grow *Mycobacterium leprae* in a culture of *Entamoeba terrapinae*.

A fragment of leproma (*L*.II), about 1 c.c. in size, had been incubated for eight days, at 25° C., in saline buffered at *p*H 7·0 with phosphates. It was thereafter inoculated into the following culture medium, called *M-E-R*: (*a*) 30 gm. of powdered skimmed milk were suspended in 200 ml. distilled water; this was autoclaved at 115° C. for 20 min. and cooled. (*b*) A whole egg (about 60 ml.) was aseptically homogenized either by hand-shaking in a flask containing glass beads or by the use of a mechanical mixer. (*c*) Milk (*a*) and egg (*b*) were mixed together and the mixture aseptically distributed (18 ml.) into sterile test tubes (dia. 25 mm.). (*d*) 2 ml. of an autoclave-sterilized solution of reductose (2·5 per cent in water) were aseptically added to each tube.

(A variant of medium *M-E-R*, used later on and called *M-E-R-M*, differed from it only in that solution (*a*) contained, in addition to the milk powder, 0·6 gm. gastric mucin.)

After incubation at 25° C. for several weeks, the microscopic examination of medium *M-E-R* inoculated with leproma *L*.II revealed the presence of an exceedingly large number of bundles of acid-fast bacilli recalling the typical 'globes' seen in the cells of lepromatous lesions.

However, only one out of three identical tubes inoculated likewise with fragments of the same leproma *L*.II gave such positive results. This suggested that contaminating microflora might be involved. From the single tube in which a multiplication of *M. leprae* had apparently occurred, four micro-organisms were isolated by standard procedures. Two were aerobes, an anthrax-like bacillus and a species of *Neisseria*. Two were anaerobes, an agar-liquefying organism and a gas-producing *Clostridium*.

My initial observation was repeated with three other specimens (*L*.I from the same patient as *L*.II, *L*.III and *L*.IV from two other patients) using the following procedure: (*a*) incubation of the fragment from leproma (about 1 c.c.) at 25° C. during at least 8 days in buffered saline (*p*H 7·0); (*b*) inoculation of the four micro-organisms together in a tube of medium *M-E-R* (or *M-E-R-M* in the case of specimen *L*.IV) and incubation during about 24 hr. (the medium is then clotted); (*c*) introduction of the macerated fragment (*a*) on the surface of (*b*) and incubation at 25° or 34° C., the tubes being tightly capped.

After one week, the clotted medium was liquefied and the proliferation of the symbionts could be stopped by the addition of either 'Sigmamycine' (a platinum loop of the dry product) or malachite green (1 ml. of a 0·5 per cent sterile solution in water) or both. However, this step was optional since it did not influence at all the evolution of *M. leprae* as observed monthly in Ziehl-stained smears.

In primary cultures, bundles of acid-fast bacilli increased and diminished in number alternately several times. They were preferably localized at the surface of the medium and in the ring which was progressively formed on the glass just over the surface. When occurring singly, bacilli were granular in appearance, but this happened very rarely as they were mostly seen in three-dimensional dense bundles or in one-plane clumps. Sometimes the agglomerates were rather loose and sometimes disintegrated into separate individuals in the immersion oil. There was no macroscopic difference between a culture in which *M. leprae* were multiplying and one inoculated with the symbionts only. Some observations, which, however, required further confirmation, led me to believe that the anthrax-like bacillus is the organism responsible for making medium *M-E-R* suitable for the growth of *M. leprae*.

Secondary cultures from the primary tubes were obtained in two ways. Either in medium *M-E-R*, using then a large inoculum representing at least one-fifth of the volume of culture, or on agar-media of various composition containing malachite green, using such an inoculum that, after partial desiccation, it left a heavy and creamy layer on the surface. Further sub-cultivation has so far been unsuccessful.

I now have on hand four suspensions very rich in bundles of *M. leprae* and aged respectively 12 (*L*.II), 11 (*L*.I and *L*.III) and 8 (*L*.IV) months. The possibility of subcultivating from them on an agar-medium gives us the hope of devising a method for the easier preparation and standardization of large amounts of lepromin.

R. Devignat

Institut d'Enseignement médical
et Ecole de Médecine Tropicale,
d'Elisabethville,
Katanga.

Rhamnose for Detection and Isolation of *Azotobacter vinelandii* Lipman

During investigations on the utilization of pentoses by *Azotobacter* spp., *A. vinelandii* proved to be the only species able to utilize rhamnose as sole carbon source. The experiments were carried out with a nitrogen-free nutrient solution containing mineral salts, 0·1 per cent agar and 1·0 per cent rhamnose as source of carbon and energy. The growth was estimated by comparison with check cultures without carbon source, and in a few cases the nitrogen fixation was determined by Kjeldahl analysis.

Twenty-eight strains of *A. chroococcum* and nine strains of *A. beijerinckii* were tested, and all were found completely unable to utilize rhamnose. Of *A. vinelandii* ten strains were tested, and nine grew as well or better with rhamnose as sole source of carbon as with glucose. One strain showed only slight, but unmistakable, growth with rhamnose as carbon source. In the nitrogen fixation experiments 14·1–15·8 mgm. nitrogen was fixed per gm. of

rhamnose decomposed, and 13·3–14·4 mgm. per gm. of glucose by the same strains.

This exclusive ability of *A. vinelandii* can be used for enrichment and isolation of this species from soils and other sources, where other *Azotobacter* species are present at the same time. In the presence of *A. chroococcum*, *A. vinelandii* cannot be detected or isolated by means of the ordinary enrichment cultures with glucose or mannitol as carbon source, because *A. chroococcum* always will be entirely dominant in such cultures. In nitrogen-free enrichment cultures with rhamnose as sole carbon source, however, *A. vinelandii*, when present, will develop profusely in 3–5 days. In the absence of *A. vinelandii* other *Azotobacter* species may develop, but only after a considerably longer incubation period (1–2 wk.).

A considerable number of cultivated soils has been tested by this technique, but *A. vinelandii* was found only in a few garden soils, and always together with *A. chroococcum*. It seems to be restricted to the most fertile soils, and to occur much more sparsely than the other *Azotobacter* species. It was not possible, however, to establish more precisely the factors determining the occurrence.

VAGN JENSEN

Department of General Microbiology,
Royal Veterinary and Agricultural College,
Copenhagen.

VIROLOGY

Mutation in Tobacco Mosaic Virus induced by a New Carcinogen, 4-Nitroquinoline N-Oxide

SEVERAL reports on the mechanism of mutation induced by nitrous acid in tobacco mosaic virus (TMV) phages T_2, T_4, τ × 174, and in transforming deoxyribonucleic acid (DNA), have been published. These indicate that, with nitrous acid treatment, inactivation and mutation occur at the same time, and therefore either may be due to a single chemical alteration in nucleic acid.

Recent experiments on the effects of 4-nitroquinoline N-oxide (4-NQO) on TMV have demonstrated that this new type of powerful carcinogen[1,2], within a certain wide range of concentrations: (1) does not inactivate TMV, although inactivating its ribonucleic acid in proportion to the concentration; (2) induces mutation in both TMV and TMV-RNA, but at a much higher rate in the latter than in the former. That 4-NQO may induce mutation without involving a change in the infectivity of TMV suggests the possibility of considering inactivation and mutation separately, and leads us to believe that the mutagenic mechanism of 4-NQO may be basically different from that of nitrous acid.

Inactivation tests. Aliquots of 1 γ/ml. TMV solution and of 290 γ/ml. solution of TMV-RNA extracted with phenol, both in 10^{-2} *M* phosphate buffer of *p*H 7·4, were each mixed with equal volumes of 4-NQO solutions in such final concentrations as shown in Table 1, and the mixtures were allowed to stand at room temperature for 60 min., after which infectivity of each mixture was assayed. For the assay 20 half-leaves of *Nicotiana glutinosa* were used, and the infectivity was judged by the number of typical lesions per half leaf. TMV used in this experiment was the ordinary mosaic strain of the Hatano Tobacco Experiment Station. The purification of the virus was made by three cycles of differential centrifugation (Spinco model *L*) of expressed sap from the diseased leaves of *Nicotiana tabacum* L. variety White Burley, which were gathered 3–4 weeks after the virus inoculation.

The results of this experiment are shown in Table 1, in which changes in infectivity according to the concentrations of 4-NQO are expressed by the variation of the mean number of local lesions per half leaf.

Table 1. EFFECTS OF 4-NQO ON THE INFECTIVITY OF TMV AND TMV-RNA

		Concentration of 4-NQO (mol.)					
		0	$0·5 \times 10^{-4}$	1×10^{-4}	$0·5 \times 10^{-4}$	$0·5 \times 10^{-4}$	$0·5 \times 10^{-4}$
TMV	4-NQO		46·0		46·0	38·4	42·0
	Solvent only (vol. per cent ethanol in water)	44·5	43·1 (0·002)		45·2 (0·02)	37·2 (0·2)	38·2 (2)
RNA	4-NQO	57·6		68·7	40·5	19·4	6·7

In another experiment, at a fixed concentration of 4-NQO ($0·5 \times 10^{-4}$ *M*), the incubation time was changed from 0 to 1 and 3 to 6 hr., and the infectivity expressed by the average number of local lesions produced in 16 half leaves was found to be almost constant, being 22·5, 22·4, 28·3, and 28·5 respectively.

Mutagenic effect. In this experiment, the mutagenic action of 4-NQO was estimated by the number of necrotic lesions produced in the leaf of *Nicotiana tabacum* L. variety *xanthi*. It is well established that the necrotic lesion is specifically produced by a mutant of TMV.

Aliquots of 0·45γ/ml. TMV solution and 400γ/ml. TMV-RNA solution, both in 10^{-2}*M* phosphate buffer of *p*H 7·4, were each mixed with 4-NQO in such final concentrations as listed in Table 2, kept at room temperature for 60 min., and then assayed. The total number of necrotic lesions produced in 15 leaves varies according to the concentrations of 4-NQO as shown in Table 2.

Table 2. PRODUCTION OF MUTANT LESIONS IN TOBACCO LEAVES BY 4-NQO

	Concentration of 4-NQO (mol.)			
	0	1×10^{-4}	$0·5 \times 10^{-4}$	$0·5 \times 10^{-4}$
TMV*	0	3	5	2
TMV	0	4	3	5
RNA	3	18	22	15

* Refers to an experiment in which 0·45 mgm./ml. TMV solution was incubated with 4-NQO for 60 min. and assay was made by diluting the mixture to 1 : 1,000 in order to avoid any possible effect of 4-NQO itself on the le[illegible]

Control experiments in which 4-NQO solution alone was applied to tobacco leaves proved that no necrotic reaction was caused by this substance.

From the chemical point of view, it may be stated that the carbon at position 4 of the 4-NQO molecule forms a highly reactive centre, through the polar effect of the N-oxide and nitro groups, and can easily substitute with nucleophilic reagents with production of nitrous acid. Therefore, deamination by this nitrous acid also might be considered as a possible mechanism in the mutation of RNA induced by 4-NQO. As has been already reported[3,4], however, 4-NQO reacts rapidly only with SH groups at neutral *p*H and at room temperature, and under these

conditions the ultra-violet absorption of this chemical is not affected when kept mixed with any other possible cellular nucleophilic group.

Also, when TMV-RNA is treated with 4-NQO, no change could be detected in ultra-violet absorption of either substance up to 24 hr. after mixing. Further investigations on the interaction between RNA and 4-NQO are under way.

It is well known that mutagenic and carcinogenic actions are often found in one and the same substance, and the fact that 4-NQO, besides its potent carcinogenic action, possesses also remarkable mutagenicity on *Aspergillus niger*[5] and *Streptomyces griseoflavus*[6] has been reported. 4-NQO, with its characteristic chemical reactivity, may eventually serve as a unique tool in the analysis of the mechanism of mutation on the molecular basis.

Hideya Endo

Cancer Institute,
Japanese Foundation for Cancer Research,
Tokyo.

Akiyoshi Wada

Department of Chemistry,
Faculty of Science,
Ochanomizu University,
Tokyo.

Kin-ichiro Miura

Department of Biophysics and Biochemistry,
Faculty of Science,
University of Tokyo.

Zyun Hidaka
Chuji Hiruki

Hatano Tobacco Experiment Station,
Hatano,
Kanagawa-ken.

[1] Nakahara, W., Fukuoka, F., and Sugimura, T., *Gann*, **48**, 124 (1957).
[2] Takayama, S., *Gann*, **51**, 139 (1960).
[3] Endo, H., *Gann*, **49**, 151 (1958).
[4] Endo, H., *Symp. Cell. Chem.*, **10**, 105 (1960).
[5] Okabayashi, T., *Ferment. Indust.*, **33**, 513 (1955) (in Japanese).
[6] Mashima, S., and Ikeda, Y., *J. App. Microbiol.*, **6**, 45 (1958).

Hæmagglutinating Sub-units released from Newcastle Disease, Para-influenza 1 and Mumps Viruses by Treatment with Ether

It was shown originally by Hoyle[1] that influenza viruses can be split by treatment with ether into sub-units, hæmagglutinin and soluble (nucleoprotein) antigen. Recently, a study on the sub-units of Newcastle disease and mumps viruses has been published, which indicated that these viruses do not liberate hæmagglutinin on treatment with ether, but only filamentous particles of nucleoprotein nature, exhibiting complement-fixation activity[2]. Working with the Blacksburg strain of Newcastle disease, the Sendai strain of para-influenza 1 and the Enders strain of mumps viruses, we found that these viruses, on treatment with ether, released both nucleoprotein antigen and hæmagglutinin.

The viruses were isolated from infectious allantoic fluids by two cycles of alternate low- and high-speed centrifugations. Concentrated preparations containing 10^4–10^5 hæmagglutination units per ml. were stirred and treated with a half volume of ether at 15° C. for 90 min. The aqueous phase was separated by low-speed centrifugation and, after removal of the water-soluble ether, clarified by centrifugation at 17,000*g* for 45 min. to remove the intact or only partially split virus. On electron microscopic examination of the supernatant, predominantly spherical particles of about 30 mμ diameter and, in the case of Newcastle disease and mumps viruses, also long filaments, similar to those described by Schäfer and Rott[2] and Horne *et al.*[3], were seen. The highest yield of hæmagglutinin was obtained with Newcastle disease virus, the number of the hæmagglutination units recovered indicating that the particle of this virus contains at least four hæmagglutinating sub-units.

The hæmagglutinins were isolated from the suspensions of sub-units by repeated adsorption on to fowl erythrocytes and by subsequent elution. In the case of Newcastle disease virus, however, this procedure did not assure the complete removal of hæmagglutinins from the suspension of sub-units. The hæmagglutinin could be concentrated and further purified by sedimentation at 145,000*g* for 90 min.

The hæmagglutinins of the viruses investigated were non-infectious; they agglutinated fowl and guinea pig erythrocytes to the same dilution, although the virus preparations, from which they were derived, showed higher hæmagglutination titres with fowl than with guinea pig erythrocytes. They exhibited neuraminidase activity and liberated from virus hæmagglutination inhibitor, isolated from bovine serum, about the same amount of sialic acid, calculated per hæmagglutination unit, as the corresponding viruses. They did not exhibit hæmolytic properties, although the viruses investigated are all hæmolytic[4]. They were precipitated quantitatively on dialysis against distilled water, but the precipitate could not be re-dissolved in the original solvent (phosphate buffered saline *p*H 7·2). They could be stored at 3° C. for several months without any decrease in hæmagglutination activity. They were not pelleted under conditions (36,000*g* for 45 min.) sufficient for almost quantitative sedimentation of the viruses. On electron microscopic examination of samples of hæmagglutinin, spherical particles of about 30 mμ were predominant (Fig. 1).

Immune guinea pig sera were prepared against the three viruses investigated, their hæmagglutinins and, in the case of the Sendai strain of para-influenza and mumps viruses, also against the nucleoprotein antigens, respectively. The viruses did not show any relationship by cross-neutralization, hæmagglutination inhibition and complement-fixation tests. The

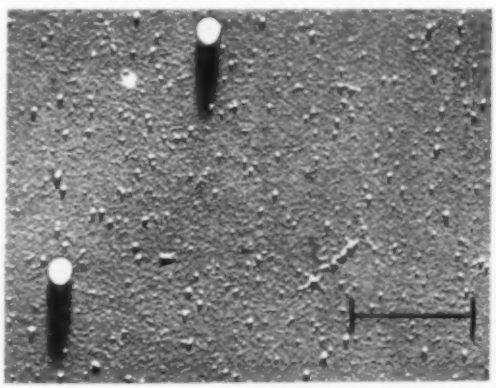


Fig. 1. Electron micrograph of para-influenza 1 virus hæmagglutinin. Scale, 1μ

same holds for their sub-units, as estimated by cross complement-fixation reactions, and in the case of haemagglutinin also by cross-haemagglutination inhibition tests.

F. Sokol
D. Blaškovič
O. Križanová-Laučíková
Institute of Virology,
Czechoslovak Academy of Sciences,
Bratislava.

[1] Hoyle, L., *J. Hyg.*, **50**, 229 (1952).
[2] Schäfer, W., and Rott, R., *Z. Naturforsch.*, **14** B, 629 (1959).
[3] Horne, R. W., Waterson, A. P., Wildy, P., and Farnham, A. E., *Virology*, **11**, 79 (1960).
[4] Andrewes, C. H., Bang, F. B., Chanock, R. M., and Zhdanov, V. M., *Virology*, **8**, 129 (1959).

CYTOLOGY

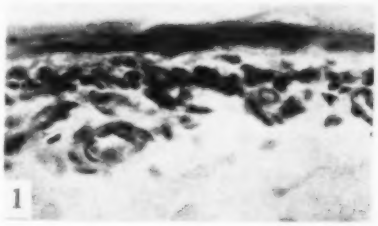
The Stainable Mucin of Joint Tissues and Synovial Fluid

Joint synovial fluid is considered to be a dialysate of blood with added mucin, which consists of hyaluronic acid[1]. The source of the latter is uncertain, but the belief is current that the synovial membrane is the likely site of formation. Articular cartilage is said to contain no hyaluronic acid, and the sulphated mucopolysaccharide it does contain is not found in appreciable quantity in synovial fluid. Synovial membrane is not lined by an epithelium, but is composed of fine, compact connective tissue of variable cellularity[2], the cells being indistinguishable from fibroblasts by electron microscopy[3]. Claims have been made that the 'membrane', especially in its superficial part, stains with mucicarmine[4–6], and also reacts with the periodic acid – Schiff technique[3]. Metachromasia, which might indicate the presence of hyaluronic acid in the membrane, has not been unequivocally demonstrated; some claim that the membrane is metachromatic[6,7], but others deny it[3,5].

In the present work, specimens of synovial membrane were removed immediately after death from the parapatellar region of the knee-joint of 5 rats, 10 guinea pigs, 10 rabbits, 10 cats, 5 dogs, 5 sheep and 4 monkeys, and from 4 human subjects at post-mortem. In addition, specimens of articular cartilage were taken from the distal femoral condule, and of fibrocartilage from the articular disks of rats, guinea pigs, rabbits, cats, dogs and monkeys. The fixative most often employed was 80 per cent alcohol, but Heidenhain's 'susa' was also used; the results were similar with both fixatives. Paraffin sections from each specimen were stained with hæmatoxylin and eosin, Southgate's mucicarmine and 0·5 per cent aqueous toluidine blue, whereas others were treated by the periodic acid – Schiff technique. A hyaluronidase (bovine, testicular) control was used with all the mucin-staining methods and a saliva (diastase) control as well with the periodic acid – Schiff technique.

The results obtained with each technique were precisely the same in all species examined. The distribution of mucinous material in the tissues, as shown by mucicarmine staining, was similar to that of the metachromatic material revealed with toluidine blue, but was different from the mucopolysaccharide distribution shown by the periodic acid – Schiff technique.

In synovial membrane, the only staining observed with mucicarmine was a faint coloration of the intercellular material, similar to that of connective tissue fibres generally, and with toluidine blue no metachromasia was observed, except in mast cells in the deeper part of the membrane. With the periodic acid – Schiff technique, some specimens of mucous membrane showed a weak reaction in the fibrous groundwork between the cells; but it was no greater than that given by connective tissue fibres in other parts of the section, and normally was weaker than the reaction seen in the walls of blood vessels. In a few instances, a fairly thick layer of precipitated synovial fluid was present, in contact with, or slightly separated from, the synovial membrane, and this material stained strongly with mucicarmine (Fig. 1), and stained metachromatically with toluidine blue. Only a weak reaction was given with the periodic acid – Schiff technique. The results obtained with all three techniques were uninfluenced by pre-treatment of the section for 24 hr. in buffered hyaluronidase at *p*H 6·9.



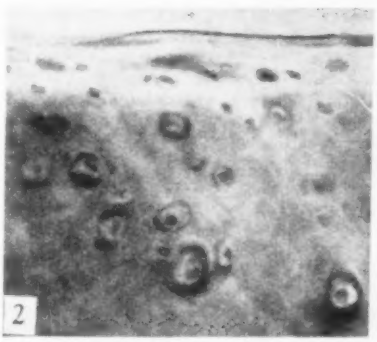


Fig. 1. Mucicarmine and hæmatoxylin preparation of human synovial membrane. Layer of precipitated synovial fluid is strongly stained with mucicarmine. (× 360)

Fig. 2. Mucicarmine and hæmatoxylin preparation of rabbit articular cartilage. General matrix is irregularly stained, but perilacunar haloes strongly stained; less staining near free surface. (× 460)

It is generally appreciated that articular cartilage contains stainable mucin, and that the distribution of the material shown with the periodic acid – Schiff technique differs from that revealed with mucicarmine. This was confirmed in the present work. With the periodic acid – Schiff technique, the whole matrix reacted moderately and evenly throughout, but no reaction was seen in the shrinkage spaces within the lacunæ. The cartilage cells, as is well known, contain glycogen, and it was confirmed that they give a positive periodic acid – Schiff reaction, which is abolished by pre-treatment with saliva. The distribution of material stainable with mucicarmine was found to be similar to that of metachromatic material, but was quite different from that of periodic acid – Schiff positive material. The matrix immediately around the lacunæ stained

strongly, in the form of haloes, but the staining of the general matrix was blotchy and irregular: towards the free surface of the cartilage there was a marked decline in the amount of stainable material in both the general matrix and in the perilacunar haloes, but small amounts were present here and there, even adjacent to the free surface (Fig. 2). The claim that cartilage cells contain stainable mucin was not confirmed; under oil immersion, it was observed that the material stainable with mucicarmine and metachromatic with toluidine blue occupies the shrinkage space between the cell and lacunar margin, and is often seen to be drawn into strands where the cell has shrunk away from the lacuna. The histological picture suggests that the cell secretes a mucinous material into the lacuna, whence it is incorporated into the perilacunar matrix, and thence passes into the general matrix, where it has an irregular distribution, and declines in amount towards the free surface of the cartilage. In articular disks, the cartilage is usually of the hyaline variety towards their free margins, and here the stainable mucin showed the same distribution as that described here. As in synovial fluid, pre-treatment with hyaluronidase did not influence the periodic acid–Schiff reaction, nor the mucicarmine or the metachromatic staining.

From the present work, it is concluded that there is insufficient evidence to show that the stainable mucin of synovial fluid is produced, at least in any quantity, from normal synovial membrane. Regarding articular cartilage, it can be said that it contains an appreciable quantity of material which stains with mucicarmine and is metachromatic with toluidine blue, and also contains material with a different distribution, which gives a positive reaction with the periodic acid–Schiff reagent. Precipitated synovial fluid also contains such material, and in neither site was the staining result influenced by hyaluronidase. Although cartilage may not contain hyaluronic acid, it seems conceivable that mucinous material of some kind may be added to synovial fluid from the wear and tear of cartilage, though present chemical evidence is not in accord with this view.

B. F. Martin

Department of Anatomy,
The University,
Sheffield, 10.

N. E. Shaw

Royal National Orthopaedic Hospital,
Stanmore, Middlesex.

[1] Ogston, A. G., and Stainer, J. E., *J. Physiol.*, **119**, 244 (1953).
[2] Petersen, H., in von Möllendorff's *Handbuch der mikroskopischen Anatomie des Menschen*, **2**, 2, 521 (Springer, Berlin, 1930).
[3] Lever, J. D., and Ford, E. H. R., *Anat. Rec.*, **132**, 525 (1958).
[4] Cherry, J. H., and Ghormley, R. K., *J. Bone Jt. Surg.*, **20**, 48 (1938).
[5] Davies, D. V., *J. Anat.* (Lond.), **77**, 160 (1943).
[6] Meibach, E., *Acta Anat.*, **17**, 175 (1953).
[7] Wislocki, G. B., Bunting, H., and Dempsey, E. W., *Amer. J. Anat.*, **81**, 1 (1947).

Nucleic Acid Content of Haploid and Diploid Cells of *Protomyces inundatus*

Protomyces is a fungus of uncertain taxonomic position and its life-history is incompletely known. In particular, previous investigators[1,2] have been unable to determine satisfactorily the position of meiosis. In the course of a taxonomic investigation into the genus *Protomyces*, a number of standard staining techniques was employed in an attempt to demonstrate meiosis, but up to now none has proved satisfactory. In view of the recent demonstration of a linear relationship between deoxyribonucleic acid (DNA) content and ploidy in a polyploid series of *Saccharomyces*[3], we decided to use DNA estimation as the basis of a method for distinguishing between haploid and diploid stages in *Protomyces*.

Stock cultures of *P. inundatus* were established on its natural host *Apium nodiflorum*, in the greenhouse: chlamydospores formed readily in such infections. Single-spore cultures were established by means of a dummy objective from: (*a*) unfused endospores obtained from germinating chlamydospores; (*b*) fusion bodies formed by the conjugation of two endospores; (*c*) cultures of budding cells obtained from mycelium within the host by plating out sterilized fragments of leaf tissue containing only vegetative mycelium.

Cultures obtained by all three methods were grown on a basal semi-synthetic liquid medium[4] with glucose as carbon source on a shaker at 20° C. The results were converted to a per cell basis by counting the cells in a small aliquot by means of a haemocytometer. Nucleic acids were determined by the method of Ogur *et al.*[5]. RNA, together with metaphosphate, was extracted in 10 per cent perchloric acid overnight at 3° C. Labile and total phosphate were determined colorimetrically using ammonium molybdate and stannous chloride, and from the values obtained metaphosphate and RNA phosphate[5] were calculated. RNA was also determined by the orcinol method of ribose estimation[6] and gave results in good agreement with those obtained by phosphorus estimation. DNA was extracted in 5 per cent perchloric acid at 70° C. for ten minutes and determined as total phosphate. Insoluble nitrogen was determined by the semi-micro Kjeldahl's method. Cell volume was calculated from measurements of major and minor axes of a hundred cells, assuming the shape of the cells to be that of an ellipsoid.

The results obtained are presented in Table 1. In a second experiment, confined to the determination of nucleic acids, the relative amounts of DNA and RNA in unfused endospores and fusion bodies were similar to those found in the first experiment. Different values on a per cell basis were obtained, however, possibly because the cultures were gathered 12 days after inoculation as opposed to 25 days in the first experiment; the cells were probably in a more actively dividing condition than those analysed in the first experiment.

Table 1. Nucleic Acid Contents and other Characteristics of Cells from Three Stages of *P. inundatus*

	Cultures derived from: (*a*) Unfused endospores	(*b*) Fusion bodies	(*c*) Mycelium in host
DNAP/cell (μgm.)	$1{\cdot}42 \times 10^{-5}$	$2{\cdot}85 \times 10^{-5}$	$2{\cdot}84 \times 10^{-5}$
RNAP/cell (μgm.)	$1{\cdot}70 \times 10^{-5}$	$1{\cdot}85 \times 10^{-5}$	$1{\cdot}84 \times 10^{-5}$
Meta-P/cell (μgm.)	$2{\cdot}19 \times 10^{-6}$	$2{\cdot}35 \times 10^{-6}$	$2{\cdot}34 \times 10^{-6}$
Insoluble N/cell (μgm.)	$1{\cdot}59 \times 10^{-7}$	$1{\cdot}97 \times 10^{-7}$	$1{\cdot}77 \times 10^{-7}$
Dry weight/cell (μgm.)	$5{\cdot}77 \times 10^{-6}$	$5{\cdot}68 \times 10^{-6}$	$5{\cdot}62 \times 10^{-6}$
Vol./cell (μ^3)	53·21	55·43	54·72

The above results indicate that there is a doubling of the DNA content following fusion and that this is maintained throughout the rest of the life-cycle up to chlamydospore formation. There is thus a strong suggestion that meiosis occurs in the chlamydospores, in the stage preceding the formation of the endospores. Having now ascertained where meiosis is likely to occur, and by concentrating cytochemical investigations on this stage, it should be possible to

find out if this is the case or not. The metaphosphate content of the cell is high, and this may be the reason why most nuclear stains tried, stained the cytoplasm as well as the nucleus. By growing single spore colonies on a medium devoid of phosphorus it has been possible to show the nucleus. One of the striking features of the results is that the RNA content of diploids is only very slightly greater than that of haploids. This situation is in contrast to that found by Ogur *et al.*[3] in yeast, where the RNA content, like that of DNA, was an indication of ploidy. The values of metaphosphate, dry weight, insoluble nitrogen and volume, like that of RNA, are all similar in haploid and diploid cells of *P. inundatus* and the only significant difference detected is in the DNA content.

The measurement of DNA content appears to be a valuable method of determining the position of meiosis in cases where cytological methods give unsatisfactory results. While the DNA content in both *Protomyces* and yeast appears to be a reflexion of ploidy, the RNA content appears to be related to the metaphosphate, insoluble nitrogen, dry weight and volume of the cell. *Allomyces*[7] and *Enteromorpha*[8] like *Protomyces* are examples of natural diploids the cells of which are about the same size as those of haploids. In most cases where diploids are produced artificially, for example *Aspergillus*[9] and *Aspidium*[10], they are double that of the haploids. Yeast is one of the few cases found in Nature in which diploids are twice the size of haploids. A knowledge of the RNA contents of haploid and diploid cells of other types of organisms would be of great interest.

Giant cells have been obtained in our cultures by the use of camphor[11] and are being examined biochemically. By comparing these giant cells, which may be diploids, with naturally occurring ones we hope to elucidate the contrast between diploid cells of *Protomyces* and those of yeast.

L. R. G. Valadon
J. G. Manners
A. Myers

Department of Botany,
University of Southampton.

[1] Von Buren, G., *Beitr. z. Krypt. d. Schweiz.*, **5**, i, 1 (1915); iii, 1 (1915–1923).
[2] Dangeard, P. A., *Le Botaniste*, 9e Serie, 263 (1903–1906).
[3] Ogur, M., Minckler, S., Lindegren, G., and Lindegren, C. C., *Arch. Biochem. and Biophys.*, **40**, 175 (1952).
[4] Lilly, V. G., and Barnett, H. L., *Physiology of the Fungi* (McGraw-Hill, 1951).
[5] Ebel, J. P., *Bull. Soc. Chim. Biol., Paris*, **34**, 491 (1952).
[6] Paech, K., and Tracey, M. V., *Modern Methods of Plant Analysis*, **4**, 291 (1955).
[7] Hatch, W. R., *Ann. Bot.*, N.S., **2**, 583 (1938).
[8] Ramanathan, K. R., *Ann. Bot.*, N.S., **3**, 375 (1939).
[9] Heagy, F. C., and Roper, J. A., *Nature*, **170**, 713 (1952).
[10] Lawton, E., *Amer. J. Bot.*, **19**, 303 (1932).
[11] Thavsen, A. C., and Morris, M., *Nature*, **152**, 523 (1943).

GENETICS

Pulmonary Tumours, Group VII and Sex in the House-Mouse

Although the exact number of factors concerned in the inheritance of susceptibility to pulmonary tumours in the house-mouse is still unknown, experiments by various workers[1–4] have suggested the presence of one major factor in linkage group VII: this factor is here termed *Tm*. A series of experiments has been undertaken to confirm the existence of this factor and to obtain an estimate of its position in group VII. The following is a preliminary report of the results of the first experiments in the series.

Mice of the following stocks were used: high susceptibility—strain *A/Cam*; low susceptibility—vestigial tail-wavy-2 (*vt–wa*-2); homozygous Rex (*Re*); *CBA/FaCam*

Strain *A* animals of both sexes were mated to the two mutant stocks, and the F_1, again of both sexes, were back-crossed to multiply recessive, low susceptibility stocks. The offspring, which totalled more than 1,000, were injected intraperitoneally at eight weeks of age with 0·5 mgm. 1 : 2 : 5 : 6-dibenzanthracene suspended in 0·5 ml. horse serum. They were killed six months later and their lungs placed immediately in Tollyesniczky's fluid. The number of nodules present on the surface was counted 24 hr. later. This number was taken as a measure of susceptibility. For a preliminary analysis all animals without tumours were classified as non-tumourous and animals with tumours, whether one or more were present, were classified as tumourous.

wa-2, *vt* and *Re* were chosen as markers to represent group VII as they have minimal effect on weight. This is of importance, because weight is known to affect susceptibility, and interaction between weight and susceptibility can mimic linkage in linkage experiments that only involve one of the linkage phases.

The recombination values obtained for *wa*-2–*Tm* and *vt*–*Tm* were different from 50 per cent at the 1 per cent level of probability (Table 1). These values, and the others involving *Tm*, are calculated from coupling-phase data only. Further experiments in this series will provide repulsion-phase data, thus giving balance and allowing corrections for disturbed viability and misclassification. However, the data related to *Tm* and sex are balanced (that is, there are approximately equal quantities from both phases), and controls are available in the form of data from females heterozygous for *Tm*. The significantly low value for *Tm*–sex† is heterogeneous from a 'linkage' point of view and is due to the homogeneously higher susceptibility of females[4].

Table 1. Recombination Values involving *Tm*

Pairs of factors	Phase balance	n	r	χ^2 (1 : 1)	$\frac{r}{r+n}$
vt — *Tm*	*U*	415	334	8·76*	44·593
wa-2 — *Tm*	*U*	421	328	11·55*	43·792
Tm — sex	*B*	134	159	2·13	54·266
Tm — sex†	*B*	255	201	6·39‡	44·079
Tm — sex	*U*	58	69	0·95	54·331
Tm — *Re*	*U*	60	67	0·39	52·756

n, non-recombinants; r, recombinants; *U*, unbalanced data; *B*, balanced data.
* Significant at the 1 per cent probability-level.
† Significant at the 5 per cent probability-level.
‡ Data from heterozygous females.

The significant recombination values confirm the association between susceptibility and group VII and clearly demonstrate the existence of a susceptibility locus (or loci) in this region of the linkage group. As the order in group VII is known to be *wa*-2–*vt*–*Re*, and as *Re* gives a value close to 50 per cent with *Tm*, *Tm* is best accommodated on the opposite side of *wa*-2 to *Re*: the tentative order being *Tm*–*wa*-2–*vt*–*Re*. The order is tentative because misclassification of *Tm* certainly occurs to some degree in these results. An excess of *Tm* can occur when mice with any number of tumours are classified as *Tm*+, and this may be severe enough to mask the true position. This diffi-

Table 2. Recombination Values for the Group VII Markers and Sex

Pairs of factors	Phase balance	n	r	χ^2 (1 : 1)	$\frac{r}{r+n}$
vt — *wa*-2	*U*	1,346	459	435·88*	25·429
vt — sex	*R*	386	383	0·01	49·805
vt — sex†	*R*	606	594	0·12	49·500
wa-2 — sex	*R*	370	353	0·40	48·824
wa-2 — sex†	*R*	525	557	0·95	51·479
Re — sex	*U*	78	90	0·86	53·571

The data not involving *Tm* are twice as large as the rest because they include all the mice that were classified at birth for sex, *wa*-2, *vt* and *Re* and which died before classification for *Tm* was possible.
* Significant at the 1 per cent probability-level.
† Data from heterozygous females.

culty should be cleared up when repulsion-phase linkage data are available.

The experiments also give data on the partial sex-linkage of group VII (Table 2), a matter about which there has been some doubt. There is no indication of partial sex-linkage such as Wallace[3] found for *wa*-2 and shaker-2 (*sh*-2) or as Carter and Phillips[6] found mimicked in the offspring of heterozygous females.

More detailed discussion and analysis of these results are to be published elsewhere.

I thank Dr. M. E. Wallace for constant advice and encouragement and much helpful discussion. Part of this work was supported by a scholarship from the Medical Research Council.

J. A. H. Tatchell

Department of Genetics,
University of Cambridge.

[1] Heston, W. E., *J. Nat. Cancer Inst.*, **2**, 127 (1941).
[2] Heston, W. E., Deringer, M. K., Hughes, I. R., and Cornfield, J., *J. Nat. Cancer Inst.*, **12**, 1141 (1952).
[3] Burdette, W. J., *J. Thorac. Surg.*, **24**, 427 (1952).
[4] Heston, W. E., *Nature*, **172**, 1067 (1953).
[5] Wallace, M. E. (= Wright), *Heredity*, **1**, 349 (1947).
[6] Carter, T. C., and Phillips, R. J. S., *Z. indukt. Abstamm.-u. Vererb.-Lehre*, **85**, 564 (1953).

Existence of Multiple Sex Genotypes in the Hermaphrodite Polychaete Worm *Ophryotrocha puerilis siberti*

It was demonstrated in 1951 that *Ophryotrocha puerilis* shows a marked sex variability, as the age when each individual passes from the male to the female sex phase is highly variable. *O. puerilis* can thus be considered as an unbalanced hermaphroditic species[1].

It was shown later that individuals of *Ophryotrocha puerilis* collected in the Bay of Naples and individuals of the same species collected in Plymouth Sound belong to two different sub-species[2]. Small oocytes first appear in isolated Naples individuals at a mean size of eighteen chætigerous segments, whereas in isolated Plymouth individuals they appear at a mean size of twenty chætigerous segments and therefore the two sub-species differ in the relative duration of the male and female phases. The former hypothesis of a genetical basis for sex variability inside each population is thus strongly supported.

The genetic nature of such variability was later demonstrated by the successful selection for the prolongation of the male phase and for the anticipation of the female phase[3]. Individuals that never passed to the female phase or which began to show oocytes at the mean length of 25 segments only were obtained at the fourth generation from a strain which passed to the female phase at a mean length of about 18 segments in the first generation. Selection against duration of the male phase produced individuals which began to show oocytes at 11 segments in a generation the individuals of which passed to the female phase at a mean length of 13 segments.

This series of experiments, which was interrupted in 1955, lead to a revision of the traditional interpretation of sex determination in hermaphrodites, and it has been resumed using the same technique but examining groups of more numerous individuals in each generation. Individuals have been examined three times a week.

Experiments are still going on, and their results are confirming and extending results obtained in the first series of experiments.

Crosses have started from one pair of individuals which were collected at Roscoff and thus belong to the Atlantic sub-species *O. puerilis siberti*. Their sons ($n = 148$), which form the 0 generation, pass from the male to the female phase at a mean length of 18·8 segments, which is a little lower than the mean which is characteristic for the sub-species. In the following generation the sons of the specimens that were selected for maleness ($n = 350$) begin to show oocytes at mean values of 20·9 segments, the sons of the specimens selected for femaleness ($n = 340$) pass to the female phase at about 18 segments and the mean falls a little below 17 segments in the second generation ($n = 285$, $\bar{m} = 16{\cdot}85$). Selection for the anticipation of the female phase at generation 3 has given a mean value of 16·44 in 170 individuals examined so far.

The mean lengths for the appearance of oocytes in the groups selected for the duration of male phase rise in generation 2 to about 22 segments ($n = 291$, $\bar{m} = 21{\cdot}75$) and they rise again very nearly 23 segments at generation 3.

Crosses between individuals of the second generation, which showed oocytes at 15 segments, and individuals of the first generation, which showed oocytes at 23 segments, produced groups of individuals (370 individuals altogether) which passed to the female phase at mean lengths between 18·64 and 18·69 segments, which scarcely differ from the mean obtained in the 0 generation (18·79).

This last result was to be expected on the basis of the crosses published in 1955. It falls in line with results obtained in classical research work on polygenic determination. Present experiments are showing the efficiency of selection in the next generations, which are now being investigated.

The various types of crosses and the various results inside the two lines selected for maleness and for femaleness, which may be called arrhenogenous and thelygenous lines[4], will be discussed in detail in a forthcoming paper. The existence of multiple sex genotypes is nevertheless wholly confirmed in *Ophryotrocha*. The so-called polyfactorial sex determination was demonstrated some time ago for some gonochoric cyprinodont species by Breider and by Kosswig[5], for the hermaphrodite polychaete worm *Ophryotrocha* in 1955. This mechanism now awaits application to the phenomena of sex variability in heterogonic cycles[4], and also to the phenomena of relative sexuality as defined by Hartmann.

G. Bacci
O. Bortesi

Istituto di Zoologia,
Università di Modena.

[1] Bacci, G., *Experientia*, **7**, 222 (1951).
[2] Bacci, G., and La Greca, M., *Nature*, **171**, 1115 (1953).
[3] Bacci, G., *Pubbl. Staz. Zool. Napoli*, **26**, 110 (1955).
[4] Bacci, G., *Rend. Acc. Naz. Lincei*, **23** (8), 165 (1957).
[5] Breider, H., and Kosswig, C., *Verh. Deutsch. Zool. Ges.*, 275 (1937).

AGRICULTURE

Amines in Silage

In 1908 Russell, referred to by Watson[1], reported that silage contained "in addition to ammonia, amines such as pentamethylene diamine, betaine, adenine, and other unidentified purin bodies". Barnett, in his book about silage fermentation[2], expressed the opinion that putrescine and cadaverine would be present in very poor silages as products of putrefaction.

In the course of work on the chemical composition of grasses and legumes during the ensiling process, silage was prepared in plastic jars (each jar containing about 2 kgm. fresh material) from fresh green maize and lucerne. After 83 days, the maize silage had a *p*H of 3·8 and showed all the characteristics of normal fermentation. The presence of tyramine was established by chromatography[3]. Further proof of its identity was obtained by cutting out an area corresponding to the tyramine spot on the chromatogram which was not developed by ninhydrin, and eluting with warm 95 per cent ethanol. The ethanol was evaporated *in vacuo*, and the residue tested for tyramine by the 1-nitroso-2-naphthol reagent[4].

When fresh green maize was tested for amines before ensilage, no tyramine was found.

Silage from fresh green lucerne was prepared under the same conditions with the further addition of 1·0 per cent sugar. In addition to tyramine at least two more amine spots appeared to be present. One had R_F 0·81 and is possibly phenylethylamine (blue colour when developed with ninhydrin); the other one had R_F 0·50 (brown colour), and might be serotonin. The eluting solvent used was butanol/acetic acid/water (120 : 30 : 50).

Tyramine and serotonin are known to exert strong physiological effects in the animal body. The possibility that these amines might interfere with consumption of silage by cattle is under investigation.

H. Neumark

Division of Animal Husbandry,
National and University Institute of Agriculture,
Rehovot,
Israel.

[1] Watson, S. J., and Nash, M. J., *The Conservation of Grass and Forage Crops*, 230 (Oliver and Boyd, London, 1960).
[2] Barnett, A. J. G., *Silage Fermentation*, 119 (Butterworths Scientific Publications, London, 1954).
[3] Awapara, J., Davis, Virginia E., and Graham, Odette, *J. Chromatography*, **3**, 11 (1960).
[4] Udenfriend, S., and Cooper, J. R., *J. Biol. Chem.*, **196**, 227 (1952).

MATHEMATICS

Relationship between the True and Mean Anomalies

For an elliptical orbit, we have the following relations[1]:

$$r = \frac{a(1-e^2)}{1+e\cos\nu} \qquad \frac{dM}{d\nu} = \frac{r^2}{a^2\sqrt{(1-e^2)}}$$

whence,

$$\frac{dM}{d\nu} = \frac{(1-e^2)^{3/2}}{(1+e\cos\nu)^2} \tag{1}$$

where r, a, and e have their usual meanings, and ν and M are the true and mean anomalies, respectively.

The solution of equation (1) has been obtained in various ways[2,3] giving[2]:

$$M = \nu + 2\sum_{n=1}^{\infty}(-1)^n\left\{\frac{1}{n} + \sqrt{(1-e^2)}\right\}\varkappa^n \sin n\nu \tag{2}$$

where $\varkappa = \frac{1}{e}\left\{1-\sqrt{(1-e^2)}\right\}$, which gives[4], by Lagrange's Expansion Theorem[5],

$$\varkappa^n = \left(\frac{e}{2}\right)^n\left\{1 + n\sum_{\lambda=1}^{\infty}\frac{(2\lambda+n-1)!}{\lambda!(\lambda+n)!}\left(\frac{e}{2}\right)^{2\lambda}\right.$$

As far as terms in e^4, equation (2) gives[3]:

$$M = \nu - 2e\sin\nu + \left(\frac{3e^2}{4} + \frac{e^4}{8}\right)\sin 2\nu - \frac{e^3}{3}\sin 3\nu + \frac{5e^4}{32}\sin 4\nu$$

A simplified version of the solution to equation (1) enables this expansion to be derived rather quickly. This solution may be obtained as follows:

We have, from equation (1),

$$\frac{dM}{d\nu} = (1-e^2)^{3/2}(1+e\cos\nu)^{-2}$$

$$= (1-e^2)^{3/2}\left\{1 + \sum_{n=1}^{\infty}(-1)^n(n+1)e^n\cos n\nu\right\} \tag{3}$$

Now

$$2^{n-1}\cos^n\nu = \sigma + \sum_{\lambda=0}^{\left[\frac{n}{2}\right]}\binom{n}{\lambda}\cos(n-2\lambda)\nu, \quad n > 0$$

where, $\sigma = \frac{1}{2}\binom{n}{\frac{n}{2}}$, for n even

$= 0$, for n odd

and $\left[\frac{n}{2}\right] \equiv$ integral part of $\frac{n}{2}$.

Hence, equation (3) becomes:

$$\frac{dM}{d\nu} = (1-e^2)^{3/2}\left[1 + 2\sum_{n=1}^{\infty}(-1)^n(n+1)\left(\frac{e}{2}\right)^n\right.$$

$$\left.\left\{\sigma + \sum_{\lambda=0}^{\left[\frac{n}{2}\right]}\binom{n}{\lambda}\cos(n-2\lambda)\nu\right\}\right] \tag{4}$$

But,

$$1 + 2\sum_{n=1}^{\infty}(-1)^n(n+1)\left(\frac{e}{2}\right)^n\sigma = (1-e^2)^{-3/2}$$

Hence, equation (4) becomes:

$$\frac{dM}{d\nu} = 1 + 2(1-e^2)^{3/2}\sum_{n=1}^{\infty}\sum_{\lambda=0}^{\left[\frac{n}{2}\right]}(-1)^n(n+1)\left(\frac{e}{2}\right)^n\binom{n}{\lambda}\cos(n-2\lambda)\nu$$

Integrating with respect to ν, we obtain the solution in the form:

$$M = \nu + 2(1-e^2)^{3/2}\sum_{n=1}^{\infty}\sum_{\lambda=0}^{\left[\frac{n}{2}\right]}(-1)^n(n+1)\left(\frac{e}{2}\right)^n\binom{n}{\lambda}\frac{\sin(n-2\lambda)\nu}{n-2\lambda} \tag{5}$$

since M and ν vanish together.

From this equation, it can be seen that the coefficient of $\sin\nu$ is:

$$2(1-e^2)^{3/2}\sum_{n=1}^{\infty}(-1)^n(n+1)\left(\frac{e}{2}\right)^n\sigma' \qquad (6)$$

where, $\sigma' = \left(\dfrac{n}{\dfrac{n-1}{2}}\right)$, for n odd

$= 0$, for n even.

Extracting $\left(\frac{e}{2}\right)$ from equation (6) we obtain the expression:

$$e(1-e^2)^{3/2}\sum_{n=1}^{\infty}(-1)^n(n+1)\left(\frac{e}{2}\right)^{n-1}\sigma'$$

But,

$$\sum_{n=1}^{\infty}(-1)^n(n+1)\left(\frac{e}{2}\right)^{n-1}\sigma' = -2(1-e^2)^{3/2}$$

Hence, the coefficient of $\sin\nu$ is $-2e$ for all n, and the solution (5) may be expressed as:

$$M = \nu - 2e\sin\nu + 2(1-e^2)^{3/2}\sum_{n=2}^{\infty}\sum_{\lambda=0}^{\left[\frac{n}{2}\right]}(-1)^n(n+1)\left(\frac{e}{2}\right)^n\binom{n}{\lambda}\frac{\sin(n-2\lambda)\nu}{n-2\lambda}$$

where $n \neq 2\lambda + 1$.

As from equation (2), we obtain as far as terms in e^4, the usual expression:

$$M = \nu - 2e\sin\nu + \left(\frac{3e^2}{4} + \frac{e^4}{8}\right)\sin 2\nu - \frac{e^3}{3}\sin 3\nu + \frac{5e^4}{32}\sin 4\nu$$

C. J. Brookes

Department of Mathematics,
College of Advanced Technology,
Gosta Green, Birmingham, 4.

[1] Moulton, F. A., *An Introduction to Celestial Mechanics*, **164**, 172 (Macmillan, 1959).
[2] Brown, E. W., *An Introductory Treatise on the Lunar Theory*, 31 (Cambridge Univ. Press, 1896).
[3] Smart, W. M., *Celestial Mechanics*, 38 (Longmans, 1953).
[4] Smart, W. M., *Celestial Mechanics*, 32 (Longmans, 1953).
[5] Brown, E. W., and Shook, C. A., *Planetary Theory*, 37 (Cambridge Univ. Press, 1933).

The Complete *n*-Point Graph

A COMPLETE n-point graph consists of n points in a plane (or on the surface of a sphere), each joined to all the others by lines, not necessarily straight. The problem of determining the minimum number of intersections, m, for various values of n is being investigated.

Fig. 1

Fig. 1 shows a complete 5-graph which has 1 intersection, this being the minimum for $n = 5$.

The problem does not appear tractable analytically, so it was programmed for the University of London *Mercury* computer. The programme was written on the assumption that a minimum for $n + 1$ points can be obtained by adding an extra point in a suitable place on a minimum solution for n points. However, the computations have proved that this apparently natural assumption is false; two different minimum configurations for $n = 7$, $m = 9$ were taken and one led to the true minimum $n = 8$, $m = 18$, while the other led to $n = 8$, $m = 19$.

I thank Dr. A. D. Booth for help and encouragement.

H. P. Goodman

Department of Numerical Automation,
Birkbeck College
(University of London),
Malet Street, W.C.1.

STATISTICS

A Basic Notion in the Theory of Cognitive Systems

In a previous communication[1] a network was described which would resolve linear relations among continuous input signals. It was indicated that for times greater than the resolution time (for some intrinsic error criterion) this net could follow changing relations and thus, by means of other nets, one could observe the relations between relations and so on. The process described is essentially that of ascending a scale of logical types. To characterize this more generally, consider a binary time series $y(t)$ of discrete time t. If this contains $2^r \leqslant 2^m$ structures of length it can be described by a logical function:

$$y(t+1) = f\{y(t) \ldots y(t-m), x_1(t) \ldots x_p(t)\} \qquad (1)$$

where it is supposed that the variance $\mu(x)$ has been minimized. The x's then describe, roughly speaking, which of the 2^r structures is under consideration. But this by no means determines the function uniquely; there is an enormous redundancy of something like $2^{2^r}(2^m/m)$ possibilities (as examination of the periodic case, $r = 0$, shows). However, for realization of logical functions it is well known that there are nets which are minimal with respect to number $c(f)$ of connexions required. In this case one may expect to obtain effective unicity by requiring the minimization of a function such as:

$$H(f, x) = \log c(f) + \log \mu(x) \qquad (2)$$

If $H(f, x)_{\min.} < \log \mu(y)$ we say that (1) is a resolving transformation $f^{(1)}$ of type 1, written formally as:

$$y = f^{\bullet}x^{(1)} \qquad (1')$$

Clearly the process could be repeated on the variables x to obtain higher types, but this requires a notion, in a certain sense dual to resolving transformation, which I call selective punctuation, $y^{(1)}$. This is the insertion of a sequence $y'^{(1)}$ of length m into the signal and may be regarded as the formalization of an experiment to test whether the $x^{(1)}$ so generated by the natural continuation of $y^{(1)}$ can be resolved into an $f^{(2)}$, and so on.

M. C. Goodall

Department of Biology,
Massachusetts Institute of Technology.

[1] Goodall, M. C., *Nature*, **185**, 857 (1960).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 29

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.30 p.m.—Mr. David Attenborough: "Travels in Madagascar".

Tuesday, May 30

LABORATORY ANIMALS CENTRE (at the Royal College of Surgeons of England, Lincoln's Inn Fields, London, W.C.2), at 10 a.m.—Symposium on "Hazards of the Animal House".

INSTITUTION OF CHEMICAL ENGINEERS (at the Royal Commonwealth Society, Craven Street, Strand, London, W.C.2), at 2.30 p.m.—Symposium on "Biochemical Engineering".

Tuesday, May 30—Friday, June 2

SEVENTEENTH RADIO AND ELECTRONIC COMPONENT SHOW (at Olympia, London).*

Wednesday, May 31

BRITISH ASSOCIATION FOR COMMERCIAL AND INDUSTRIAL EDUCATION (at County Hall, London, S.E.1), at 9.30 a.m.—Exhibition and Conference on "Successful Instruction".

UNIVERSITY OF LONDON (in the Physiology Lecture Theatre, University College, Gower Street, London, W.C.1), at 5 p.m.—Dr. David B. Sprinson (Columbia University): "The Reactions of Aromatic Biosynthesis".*

INSTITUTE OF INFORMATION SCIENTISTS (at the Swedenborg Society Hall, 20 Bloomsbury Way, London, W.C.1), at 6.15 p.m.—Annual General Meeting, 7.30 p.m.—Miss M. Webb: "Some Thoughts on the National Science Reference Library".

Thursday, June 1

INSTITUTE OF PHYSICS AND THE PHYSICAL SOCIETY (in the Physics Department of Imperial College, Prince Consort Road, London, S.W.7), at 2.30 p.m.—Dr. R. W. Twiss: "On Re-designing Michelson's Stellar Interferometer"; Mr. K. Hacking: "Secondary Flare in Lenses".

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. D. W. Dresser: "A Study of the Adaptive Secondary Response to a Protein Antigen in Mice"; Mr. J. G. Howard and Mr. M. F. A. Woodruff: "Effect of the Graft-versus-Host Reaction on the Immunological Responsiveness of the Mouse".

Thursday, June 1—Saturday, June 3

BRITISH SOCIETY FOR IMMUNOLOGY (in the Edward Lewis Theatre of the Middlesex Hospital Medical School, Cleveland Street, London, W.1)—Spring Meeting.

Friday, June 2

UNIVERSITY OF LONDON (at the Postgraduate Medical School of London, Ducane Road, London, W.12), at 10 a.m.—Dr. H. E. M. Kay: "Some Relevant Problems of Homotransplantation".*

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 6 p.m.—Mr. P. D. MacMahon: "Development of Stabilizing Equipment for Helicopters".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT EXPERIMENTAL OFFICERS (2) (with a university degree in agriculture or in pure science with main subject botany or bacteriology) IN THE DEPARTMENT OF AGRICULTURE AND FISHERIES FOR SCOTLAND, for research work in the field and in the laboratory on potato black-leg disease—The Establishment Officer, Room 73, Department of Agriculture and Fisheries for Scotland, St. Andrew's House, Edinburgh 1 (May 31).

ASSISTANT LECTURERS (with particular interests in physical chemistry, inorganic chemistry or organic chemistry) IN THE DEPARTMENT OF CHEMISTRY—The Secretary, The University, Edinburgh (May 31).

LECTURER IN THE DEPARTMENT OF PATHOLOGY—The Secretary, The University, Glasgow (May 31).

LECTURER or ASSISTANT LECTURER IN PURE MATHEMATICS—The Secretary and Registrar, University College of North Wales, Bangor, North Wales (June 3).

RESEARCH DEMONSTRATOR IN THE DEPARTMENT OF PHYSICS—The Registrar, The University, Leicester (June 3).

TUTORIAL ASSISTANT IN THE DEPARTMENT OF GEOGRAPHY—The Registrar, The University, Leicester (June 3).

ASSISTANT LECTURER IN ORGANIC CHEMISTRY—The Registrar, The University, Manchester 13 (June 5).

LECTURER (Grade II) IN THE DEPARTMENT OF ORGANIC CHEMISTRY—The Registrar, The University, Bristol 8 (June 5).

LECTURER or JUNIOR LECTURER IN APPLIED MATHEMATICS—The Registrar, Trinity College, Dublin 2 (June 5).

LECTURER or ASSISTANT LECTURER (preferably qualified to carry out research in electrophysiology) IN MARINE ZOOLOGY at the Marine Biology Station—The Registrar, University College of North Wales, Bangor, North Wales (June 6).

CHAIR OF PHYSICS; and CHAIR OF CHEMISTRY (from 1962)—The Registrar, University College of Sussex, Stanmer House, Stanmer Road, Brighton (June 8).

RESEARCH FELLOW IN THE NUCLEAR PHYSICS GROUP OF THE DEPARTMENT OF PHYSICS, to prepare and participate in experiments on the 7 GeV. proton synchrotron at the Rutherford High Energy Laboratory of the National Institute for Research in Nuclear Science—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (June 8).

ASSISTANT LECTURER and a LECTURER IN PHYSICS—The Registrar, The University, Nottingham (June 10).

DEMONSTRATOR IN ZOOLOGY—The Registrar, The University, Nottingham (June 10).

LECTURER or ASSISTANT IN GEOLOGY—The Secretary of University Court, The University, Glasgow (June 10).

RESEARCH FELLOW IN THE DEPARTMENT OF BIOCHEMISTRY—The Assistant Registrar (Science), The University, Edgbaston, Birmingham 15 (June 12).

ASSISTANT LECTURER or LECTURER (honours graduate) IN MATHEMATICS—The Secretary, Bedford College, Regent's Park, London, N.W.1 (June 17).

LECTURER (graduate in science with special qualifications in botany or agricultural botany) IN BOTANY—The Secretary, The West of Scotland Agricultural College, 6 Blythswood Square, Glasgow, C.2 (June 17).

LECTURER (physicist or physical chemist, with some background in the biological sciences) IN RADIATION PHYSICS AND BIOLOGY in the Isotopes Laboratory—Joint Clerk to the University Court, Queen's College (University of St. Andrews), Dundee (June 17).

RESEARCH ASSISTANT (chemist, preferably with two or three years research experience), for work on volatile inorganic compounds in collaboration with Dr. L. H. Long—The Secretary, The University, Exeter (June 17).

LECTURER IN PHYSICAL CHEMISTRY at Makerere University College, East Africa—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (June 22).

ASSISTANT LECTURER or LECTURER IN THE DEPARTMENT OF MATHEMATICS—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (June 24).

DEMONSTRATOR or ASSISTANT IN THE SUB-DEPARTMENT OF PHARMACOLOGY, University College of the West Indies—The Secretary, Senate Committee on Colleges Overseas in Special Relation, University of London, Senate House, London, W.C.1 (June 28).

HEAD (with wide experience of research on plant diseases caused by fungi and bacteria, and preferably a special interest in microbiological problems, for example, as associated with soil or mushroom composts) OF THE MYCOLOGY AND BACTERIOLOGY DEPARTMENT—The Secretary, Glasshouse Crops Research Institute, Worthing Road, Rustington, Littlehampton, Sussex (June 30).

CHAIR OF PHILOSOPHY; and SENIOR LECTURERS or LECTURERS IN MATHEMATICS at the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, July 3).

LECTURER IN GEOGRAPHY IN THE DEPARTMENT OF METALLURGY—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

LECTURER IN MATHEMATICS; and a SENIOR LECTURER or LECTURER IN PHYSICS at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, July 15).

LECTURER IN PREHISTORY IN THE DEPARTMENT OF ANTHROPOLOGY, University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand and London, July 15).

POSTGRADUATE RESEARCH ASSISTANT (with a knowledge of X-ray diffraction methods), for studies of liquid structure under the personal supervision of Prof. J. D. Bernal—The Secretary, Birkbeck College (University of London), Malet Street, London, W.C.1.

SENIOR RESEARCH ASSISTANT (preferably with a special interest in pharmacology or physiology) IN THE ANIMAL LABORATORY OF THE DEPARTMENT OF PSYCHOLOGY, for work on variables affecting conditioned behaviour—The Secretary, Birkbeck College (University of London), Malet Street, London, W.C.1.

TECHNICIAN FOR BIOCHEMICAL WORK IN THE DEPARTMENT OF CANCER RESEARCH—The Administrative Officer, Mount Vernon Hospital, Northwood, Middlesex.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Proceedings of the Royal Irish Academy. Vol. 61, Section A, No. 2: A Note on Fermi Co-ordinates. By F. A. E. Pirani. Pp. 9–14. 1*s.* Vol. 61, Section A, No. 3: Ionization Equilibrium in Maritime Air. By T. C. O'Connor and W. P. Sharley. Pp. 15–27. 1*s.* 6*d.* Vol. 61, Section A, No. 4: On Certain Identities Connected with the Einstein Tensor. By J. L. Synge. Pp. 29–36. 1*s.* 6*d.* Vol. 61, Section A, No. 5: How to Pass to an Exact Solution of Einstein's Vacuum Field Equations, Starting from a Linear Approximation. By J. L. Synge. Pp. 37–44. 1*s.* 6*d.* Vol. 61, Section A, No. 6: On the Substitution Law in Quantum Field Theory. By D. Judge, H. Shimodaira and Y. Takahashi. Pp. 44–54. 1*s.* 6*d.* Vol. 61, Section A, No. 7: Sir Joseph Larmor and the Ionosphere. By Sir Edward Appleton, F.R.S. (Sir Joseph Larmor Memorial Lecture.) Pp. 55–66. 1*s.* 6*d.* Vol. 61, Section B, No. 11: The Action of Fatty Acids on Oxidative Metabolism. By J. M. O'Connor. Pp. 187–200. 2*s.* Vol. 61, Section B, No. 12: The Interactions of Potassium Iodide and Alkali Hypochlorite Solutions. By V. de Valera, A. Broekhoven and C. D. O'Briain. Pp. 201–218. 2*s.* 6*d.* Vol. 61, Section B, No. 13: Studies on Flowering-Plant Growth and Organo-Genesis. IV: Effects of Gibberellic Acid on Flowering and the Secondary Sexual Difference in Stature in *Cannabis sativa*. By J. Heslop-Harrison and Y. Heslop-Harrison. Pp. 219–231 + plate 12. 2*s.* (Dublin: Hodges, Figgis and Co., Ltd., 1960 and 1961.) [73

The Royal Institute of Chemistry. Index of Chemistry Films: a Comprehensive List of Films and Filmstrips on Chemistry and Related

Subjects. Second edition. Pp. viii+217. (London: Royal Institute of Chemistry, 1961.) 5s. net. [73

Institute of Brewing. European Brewery Convention. Report of the Barley Committee—Trials, 1959. Pp. 170. (London: Institute of Brewing, 1960.) [83

Bryant and May, Ltd. Making Matches 1861–1961. Pp. 28. (London: Bryant and May, Ltd., 1961.) [93

An Aspect or Order in the Physical World. By Prof. E. L. Yates. (An Inaugural Lecture given in the University College of Rhodesia and Nyasaland.) Pp. 23. (London: Oxford University Press, 1961.) 4s. net. [93

Government of Northern Ireland: Ministry of Agriculture. Leaflet No. 95: The Growing of Oats, Barley and Wheat. Pp. 15. (Belfast: Ministry of Agriculture, 1961.) [93

The Manchester Museum. Report of the Committee for the year ending July 31, 1960. Pp. 20. Pioneer Research Around Manchester—Descriptive Leaflet. Pp. 8. 6d. (Manchester: The Manchester Museum, The University, 1961.) [133

The Genesis Creation Story Through Modern Spectacles. By Percival M. Dearle. Pp. 10. (Leigh-on-Sea: Percival M. Dearle, 8 St. Clement's Court.) [133

Steel Castings Development Committee. Data Sheets on Steel Castings. Sheet No. 1: Low Temperature Properties of Plain Carbon Steel Castings. Pp. 7. Sheet No. 2: Low Temperature Properties of Pearlitic Manganese Steel Castings. Pp. 7. Sheet No. 3: Low Temperature Properties of Low and Medium Alloy Steel Castings. Pp. 7. Sheet No. 4: Magnetic Properties of Plain Carbon Steel Castings. Pp. 8. Sheet No. 5: Fatigue Properties of Steel Castings. Pp. 12. (Sheffield: Steel Castings Development Committee, 1961.) [133

South Africa: Revolution or Reconciliation? By the Rt. Rev. Richard Ambrose Reeves. (Alex Wood Memorial Lecture, 1961, delivered at Newcastle-upon-Tyne, March 3rd, 1961.) Pp. 20. (London: The Fellowship of Reconciliation, 1961.) 1s. 6d. [133

National Union of Teachers. Education Development: Some Economic and Social Considerations. By Lionel Elvin. (Based on an Address given to the Sectional Meetings of the National Union of Teachers on 4th January, 1961.) Pp. 16. (London: National Union of Teachers, 1961.) [133

Rugby School Natural History Society. The Flora of the Rugby District. By D. E. Allen. Pp. 48. 3s. 6d. A First Supplement to "The Flora of the Rugby District". By D. E. Allen. Pp. 4. 1s. (Rugby: George Over, Ltd., 1957 and 1961.) [143

Building Research Station Digest (Second Series). No. 8: Built-up Felt Roofs. Pp. 6. (London: H.M. Stationery Office, 1961.) 4d. [143

Other Countries

Food and Agriculture Organization of the United Nations. Indo-Pacific Fisheries Council Proceedings—8th Session, Colombo, Ceylon, 6–22 December, 1958. Section III: Symposium on Fish Behaviour. Edited by Dr. G. L. Kesteven. Pp. iii+116. (Bangkok: I.P.F.C. Secretariat, F.A.O. Regional Office for Asia and the Far East.) 5s.; 1 U.S. dollar. [272

Bechuanaland Protectorate. Annual Report of the Geological Survey Department for the year ended 31st December, 1959. Pp. 39. (Lobatse: Geological Survey, 1960.) [272

Official Records of the World Health Organization, No. 105: The Work of WHO, 1960—Annual Report of the Director-General to the World Health Assembly and to the United Nations. Pp. x+224. (Geneva: World Health Organization; London: H.M. Stationery Office, 1961.) 6 Swiss francs; 10s.; 2 dollars. [272

National Research Council, Ottawa. Problems of the North, No. 1, 1958. (Translation from "Problemy Severa.") Translated December, 1960. Pp. iii+376. Subscription prices: per issue 7 dollars. Single papers 1 dollar. (Ottawa: Translations Section, The Library, National Research Council, 1960.) [272

Annals of the New York Academy of Sciences. Vol. 89, Article 5: Human Decision in Complex Systems. By Warren S. McCulloch and 19 other authors. Pp. 715–896. (New York: New York Academy of Sciences, 1961.) [272

United States Department of the Interior: Geological Survey. Water-Supply Paper 1632: Surface Water Supply of the United States, 1959. Part 8: Western Gulf of Mexico Basins. Prepared under the direction of J. V. B. Wells. Pp. xi+529. (Washington, D.C.: Government Printing Office, 1960.) [272

Atomic Energy of Canada Limited. Proceedings of the Sixth Tripartite Instrumentation Conference held at Chalk River, Ontario, April 20–24, 1959. Part 1: Reactor Instruments. Pp. xi+214. 5 dollars. Part 2: Radiation Dosimetry. Pp. xi+145. 3 dollars. Part 3: System and Component Reliability. Pp. viii+19. 1 dollar. Part 4: Instruments for Nuclear Physics. Pp. xi+212. 5 dollars. Part 5: Radiation Detectors. Pp. ix+76. 2 dollars. (Chalk River, Ontario: Scientific Document Distribution Office, Atomic Energy of Canada Limited, 1960.) 15 dollars the set. [272

Publications de l'Institut National pour l'Etude Agronomique du Congo. Série Scientifique, No. 87: Etude Écologique de la Forêt Dense à *Gilbertiodendron dewevrei* dans la Région de l'Uele. Par Dr. Ph. Gerard. Pp. 159+24 photographies. 175 francs. Carte des Sols et de la Végétation du Congo et du Ruanda-Urundi. 16: Dorsale du Kivu. A: Sols. B: Végétation. C: Utilisation des Sols. Notice Explicative de la Carte des Sols et de la Végétation. Par A. Pecrot et A. Leonard. Pp. 124+4 photographies. (Bruxelles: Institut National pour l'Etude Agronomique du Congo, 1960.) [23

Smithsonian Institution: Bureau of American Ethnology. Bulletin 176: River Basin Surveys Papers, Numbers 15–20. Edited by Frank H. H. Roberts, Jr. (Inter-Agency Archeological Salvage Program.) Pp. ix+337+65 plates. (Washington, D.C.: Government Printing Office, 1960.) [63

Danish Atomic Energy Commission Research Establishment, Risö. Risö Report No. 18: International Summer Course in Plasma Physics, 1960: Material presented at the Course. Pp. viii+645. (Risö, Roskilde: Danish Atomic Energy Research Establishment, 1961.) 60 D.kr. [63

United States Department of the Interior: Geological Survey. Water-Supply Paper 1520: Quality of Surface Waters of the United States, 1957. Parts 1–4: North Atlantic Slope Basins to St. Lawrence River Basin. Prepared under the direction of S. K. Love. Pp. xvi+641. 2 dollars. Water-Supply Paper 1624: Surface Water Supply of the United States, 1959. Part 2–B: South Atlantic Slope and Eastern Gulf of Mexico Basins, Ogeechee River to Pearl River. Prepared under the direction of J. V. B. Wells. Pp. x+488. Water-Supply Paper 1635: Surface Water Supply of the United States, 1959. Part 11: Pacific Slope Basins in California. Prepared under the direction of J. V. B. Wells. Pp. xv+748. (Washington, D.C.: Government Printing Office, 1960.) [63

American Geographic Society. Special Publication No. 34: Nine Glacier Maps, Northwestern North America. Pp. iii+22+16 figures+9 maps. (New York: American Geographical Society, 1960.) 3 dollars. [63

Texas Instruments Incorporated. Annual Report for 1960. Pp. 20. (Dallas: Texas Instruments, Inc., 1961.) [63

Administration of South West Africa: Marine Research Laboratory. Investigational Report No. 1: The Pilchard of South West Africa (*Sardinops ocellata*)—Size Composition of the Commercial Catches in South West Africa, 1952–1957. By J. P. Matthews. Pp. 45 (17 plates). (Windhoek: Secretary, Administration of South West Africa, 1960.) [63

Indian Central Jute Committee. Annual Report of the Jute Agricultural Research Institute (1958–1959). Pp. 126. (Calcutta: Indian Central Jute Committee, 1960.) [63

Proceedings of the Fifth Congress on Theoretical and Applied Mechanics; and the Symposium on Non-Linear Physical Problems, Roorkee, 1959. Pp. xi+342. (Kharagpur: Indian Society of Theoretical and Applied Mechanics, Indian Institute of Technology, 1960.) [63

United States Department of the Interior: Fish and Wildlife Service. Fishery Bulletin No. 179: Growth of Bluefin Tuna of the Western North Atlantic. By Frank J. Mather III and Howard A. Schuck. Pp. iv+39–52. (Washington, D.C.: Government Printing Office, 1960.) 20 cents. [63

Metropolitan Life Insurance Company, New York. Statistical Bulletin Vol. 41 (December, 1960): The Outlook in Cancer. Accident Toll in 1960—92,000 Lives. Migration to the West Continues. The Frequency of Suicide. Pp. 12. (New York: Metropolitan Life Insurance Company, 1960.) [63

United States Department of Commerce: Coast and Geodetic Survey. Publication 20–2: Hydrographic Manual. By Captain Karl B. Jeffers. Pp. ix+283. (Washington, D.C.: Government Printing Office, 1960.) 2 dollars. [63

United States Department of Commerce: Coast and Geodetic Survey. Publication 65–1, Part 50: Plane Co-ordinate Intersection Tables (2½ minute)—Alaska, Zones 2–9. Pp. xi+211. (Washington, D.C.: Government Printing Office, 1960.) 1.50 dollars. [63

Catalogue Collectif des Livres Français de Sciences et Techniques, 1950–1960. Pp. viii+242. (Paris: Cercle de la Librairie, 1961.) [63

City of Launceston, Tasmania. Annual Report of the Director of the Queen Victoria Museum and Art Gallery, 1958–59. Pp. 8. Annual Report of the Director of the Queen Victoria Museum and Art Gallery, 1959–60. Pp. 11. Records of the Queen Victoria Museum, New Series, No. 12: Comments on the Cainozoic History of Western Tasmania. By B. Scott. Pp. 10. No. 13: Erosion Surfaces in Western Tasmania. By B. Scott. Pp. 11. (Launceston: Queen Victoria Museum and Art Gallery, 1959 and 1960.) [73

The International Nickel Company of Canada, Ltd. Annual Report, 1960. Pp. 32. (Copper Cliff, Ontario: International Nickel Company of Canada, Ltd., 1961.) [73

Canada: Department of Mines and Technical Surveys, Geological Survey of Canada. Bulletin 61: Petrology of the Gneisses of Cumberland Sound, Baffin Island, Northwest Territories. By G. C. Riley. Pp. xvi+69+10 plates. (Ottawa: Queen's Printer, 1960.) 1 dollar. [73

British Territories in Borneo: Geological Survey Department. Bulletin 3: The Geology of Sarawak, Brunei and the Western Part of North Borneo. By Dr. P. Liechti, in association with Dr. F. W. Roe and Dr. N. S. Haile. Vol. 1 (Text): Pp. xvii+360+73 plates. Vol. 2 (Portfolio): Geological Map of Sarawak, Brunei and North Borneo. Table of Rock-Stratigraphic Columnar Sections. Tectonic Map. (Kuching, Sarawak: Government Printing Office; London: Overseas Geological Surveys, 1960.) 21 Malayan dollars; 49s. the two volumes. [83

Danish Atomic Energy Commission. Report on the Activities of the Danish Atomic Energy Commission for the period from 1 April, 1959, to 31 March, 1960. Pp. 69. Risö: The Research Establishment of the Danish Atomic Energy Commission. Pp. 16. (Copenhagen: Danish Atomic Energy Commission, 1960.) [83

Western Nigeria. Annual Report on the Forest Administration of the Western Region of Nigeria for the year 1958–1959. Pp. iii+42. (Ibadan: Government Printer, 1960.) 1s. [93

Forschungsberichte des Landes Nordrhein-Westfalen. Nr. 927: Untersuchungen über die Krustenbildung an Metallischen Werkstoffen. Von Lennart Junghahn. Pp. 91. (Köln und Opladen: Westdeutscher Verlag, 1960.) 27.25 D.M. [133

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.
ST. MARTIN'S STREET, LONDON, W.C.2
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

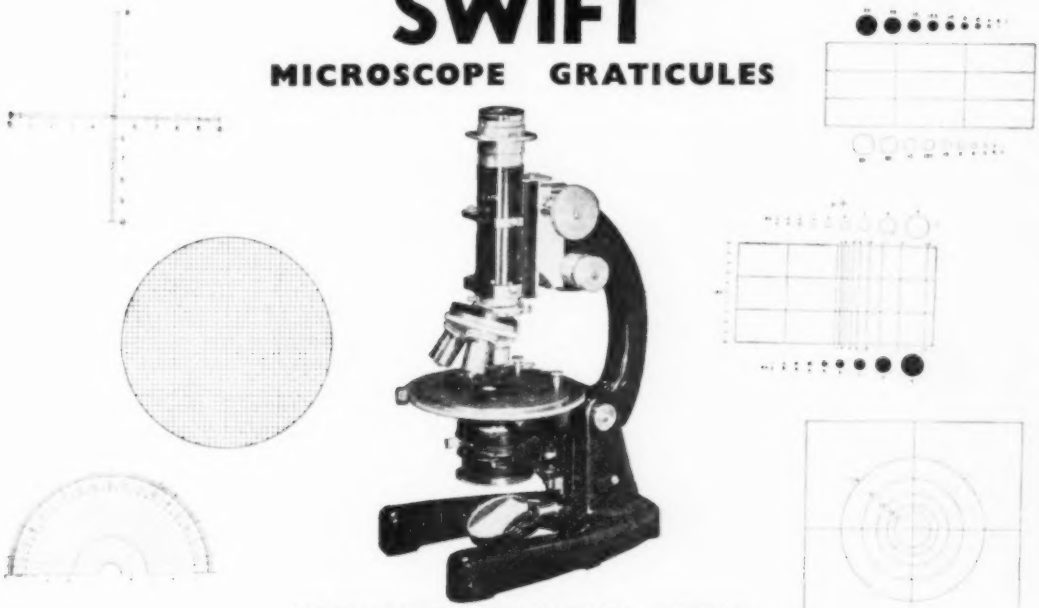
Annual subscription £8/8/-, payable in advance, postage paid to any part of the world

Advertisements only should be addressed to
T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2.
Telephone Number: Holborn 4743

All rights reserved. Registered as a newspaper at the General Post Office

SWIFT

MICROSCOPE GRATICULES



MEASURING · COUNTING · SIZING

Comprehensive brochure free on request

JAMES SWIFT & SON LTD. 113-115A CAMBERWELL ROAD, LONDON, S.E.5 RODney 5441

Plan Ahead

by effecting now "the young man's policy" which gives to a man under 35 immediate life assurance cover at low cost and the valuable right to effect within ten years further assurances even though his health has become impaired.

The Equitable has no shareholders and pays no commission for the introduction of business; unusually attractive terms can, therefore, be offered.

Write today for details to

The Equitable Life Assurance Society

(Founded 1762)

Head Office: **19 Coleman Street, London, E.C.2**

Please send me, without obligation, details of the young man's policy.

Name .....

Address .....

FOR THE RECLAMATION & SALVAGE of ELECTRONIC COMPONENTS . . . . *USE*

DE-SOLV 292

A SOLVENT FOR EPOXY & POLYESTER RESINS

Here, at last, is the answer to the problem of salvaging electronic components from rejected units where the sealing medium consists of one of the Epoxy or Polyester resins. The ease with which defective embedded units may be reclaimed eliminates the need for devoting costly man-hours to the recovery of expensive rejects.

De-Solv 292 is a non-inflammable and neutral solvent combination of low toxicity, extremely easy to use. The potted unit containing the components to be reclaimed is immersed for 8 to 12 hours in a sufficient quantity of D.S.292 in a suitable container with cover or lid which fits well. On removal, the softened resins can be brushed or rubbed away.

De-Solv 292 is economical because it can be re-used after removal of the resin particles by straining through a suitable strainer or a piece of cheese-cloth.

AVAILABLE IN SCREW-CAPPED CONTAINERS, QUARTER GALLON, HALF GALLON AND ONE GALLON. PRICES AND FULL DETAILS ON APPLICATION.

Oxley Developments Co. Ltd.

PRIORY PARK, ULVERSTON, LANCS.
Telephone: Ulverston 3306

APPOINTMENTS VACANT

AUSTRALIA

UNIVERSITY OF NEW SOUTH WALES
SENIOR LECTURER OR LECTURER SCIENTIFIC THOUGHT

The University of New South Wales wishes to appoint a Senior Lecturer or Lecturer in Scientific Thought to the School of Philosophy. The successful applicant will undertake teaching of scientific thought to students in the Faculty of Arts and may also conduct courses in the history and philosophy of science to students in other faculties. Applicants for the position of Lecturer must have a degree with honours in philosophy or a natural science, and ought to have substantial qualifications in these fields; for appointment to the position of Senior Lecturer, applicants must have a higher degree or equivalent qualifications. Salary: Lecturer, £A.1,766 range £A.2,471 per annum; Senior Lecturer, £A.2,586 range £A.3,036 per annum. The commencing salaries of these positions are determined by qualifications and experience. Successful applicant will be eligible, subject to passing a medical examination, to contribute to the State Superannuation Fund. First-class ship fares to Sydney of appointee and family will be paid. Further details about the position may be obtained from the Agent-General for New South Wales in London.

Four copies of applications (including the names of two referees) should be lodged with the Agent-General for New South Wales, 56-57 Strand, London, W.C.2, and a copy forwarded to the Appointments Section, The University of New South Wales, Box 1, Post Office, Kensington, New South Wales, Australia, by airmail to arrive before July 14, 1961. Applicants outside the United Kingdom and Eire need only send one copy of their application to the London address in addition to the copy sent to the University.

AUSTRALIA

UNIVERSITY OF NEW SOUTH WALES
BROKEN HILL DIVISION
SCHOOL OF CHEMISTRY

The University of New South Wales wishes to appoint a Lecturer to the School of Chemistry at Broken Hill.

Applicants should have a degree with honours or equivalent qualifications. Some teaching experience is desirable. As the chosen applicant will lecture on physical chemistry, experience and research interest in this field are required.

Salary: £A.1,766 range £A.2,471 per annum. Commencing salary is determined by qualifications and experience.

Payment of a climatic and disability allowance will also be made.

First-class ship fares of appointee and family will be paid. Successful applicant will be eligible to join the State Superannuation Fund.

Four copies of applications, together with the names of two referees, should be lodged with the Agent-General for New South Wales, 56 Strand, London, W.C.2, and a copy forwarded to the Appointments Section, The University of New South Wales, Box 1, Post Office, Kensington, New South Wales, by airmail to reach there before July 14, 1961.

CHEMISTS REQUIRED AT HEADQUARTERS, Ministry of Aviation, London. Post 1: Take charge of section responsible for initiating and progressing research programmes to provide hydraulic fluids and aircraft lubricants of improved performance and prepare and maintain specifications for these materials. Post 2: Initiate and control extramural research and development programmes connected particularly with use of paints and adhesives in aircraft and guided weapons; deal with problems arising from use of these materials and prepare and maintain specifications for these materials. Post 3: Initiate and control extramural research and development programmes connected with use of plastics in aircraft and guided weapons, deal with problems arising from the use of plastics and prepare and maintain specifications for plastics for use in these fields. Appointments as Principal Scientific Officer (minimum age 31) or Senior Scientific Officer (minimum age 26). Qualifications: first- or second-class honours degree, or equivalent, in chemistry and some years' postgraduate research experience in appropriate field. Salary ranges: Principal Scientific Officer, £1,781 to £2,483; Senior Scientific Officer, £1,402 to £1,719, superannuation under F.S.S.U. Opportunity for candidates under 31 to compete for established (non-contributory pensionable) posts.—Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting ref. F.263/1A and appropriate post.

AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

PHYSICIST OR PHYSICAL CHEMIST

The Organization's **Division of Forest Products, Melbourne,** invites applications for the position of Physicist or Physical Chemist with the Paper Physics Group of the Wood Chemistry Section from Honours graduates in Science (or equivalent qualifications) with some postgraduate research experience.

This Group is studying the physical chemistry of cellulose and related polysaccharides and the physics of pulp and paper. Investigations include hydrogen bonding in polysaccharide systems, the spectroscopy of carbohydrates, the rheology of paper and the hydrodynamics of fibre-water systems. Latitude in the choice of detailed problems will be permissible according to the interest of the appointee.

SALARY: Dependent on qualifications and experience within the range £A.1,510 to £A.2,265 per annum. Salary for an experienced Honours graduate will not be less than £A.1,620 per annum; and for an appointee with a Ph.D. degree, not less than £A.1,785 per annum.

Salary for a woman will be £A.180 per annum less than corresponding rates for men.

Advancement in C.S.I.R.O. is by merit and dependent on achievement, re-classification to the higher grades can be expected.

By arrangement, the appointment may be for an indefinite period or for a period of three years.

Fares paid and in the case of a short-term contract, return fares will also be paid. Further particulars on conditions, etc., supplied on application to:

Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2,

to whom applications (quoting Appointment No. 290/572) should be addressed by July 1, 1961.

CHEMICAL ENGINEER—RESEARCH

Anglo-Lautaro Nitrate Corporation, a large mining and chemical company with operations in the North of Chile, requires a B.Sc. in Chemical Engineering, age 25 to 35, preferably married, for a position in its research organization. Salary SU.S.6,600 per annum or higher depending on qualifications.

The successful candidate will be expected to take charge of pilot plant operations, perform mathematical studies of processes and related problems associated with the production of sodium nitrate, potassium nitrate, iodine and boric acid.

Opportunities for advancement may be in either administrative or scientific directions.

Applicants should have experience in industrial research or development and should have demonstrated ability in initiating research in chemical engineering and allied fields. Applications from Junior Chemical Engineers will also be considered.

The Company's operations and research laboratory are located near Antofagasta, Chile. It maintains full supporting services including a mechanical design section and large machine shop facilities.

Applications with **full details of qualifications and experience, age and family status** should be addressed to:

Mr. C. S. Hill,
Nitrate Corporation of Chile Ltd.,
20 Ropemaker Street,
London, E.C.2.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

VACANCIES IN POLYMER RESEARCH

Two graduates, preferably with some research experience, required to work with Dr. M. Gordon on the physical chemistry of polymers. One is a more senior post (possibly post-doctoral) for work in the field of the statistics and physical effects of cross-linking. Both researches could afford suitable material for submission for a higher degree.

Apply in writing, giving full academic background and the names of two referees, to Dr. M. Gordon, Chemistry Department, Imperial College, S.W.7.

GOVERNMENT OF NORTHERN RHODESIA

Male Entomologist with honours degree in zoology or kindred branch of natural science, and preferably with postgraduate training or experience in entomological field work, required to plan and prosecute tsetse control measures involving preliminary routine and special surveys of fly incidence, and to determine the most suitable methods of control. Duties also include supervision of Tsetse Control Staff (e.g., fly pickets) and specific schemes. Appointment on contract for one tour of 36 months in the first instance, with gratuity (taxable) of £37 10s. for each completed three months of service on satisfactory completion. Salary in scale £1,020 to £2,245 a year, starting point determined by age and experience. Quarters with heavy furniture available at low rental. Free return passages for officers and wife, and up to cost of one full fare for children. Income tax at local rates. Local leave permissible and home leave at the rate of five days for each completed month of resident service granted on completion of contract. Educational facilities for children available.

Application forms from Director of Recruitment, Colonial Office, London, S.W.1 (quoting BCD67/3/08).

ROYAL HOLLOWAY COLLEGE
(UNIVERSITY OF LONDON)
RESEARCH ASSISTANT FOR PHYTOPLANKTON INVESTIGATIONS

A Research Assistant is required for freshwater phytoplankton investigations, to begin if possible in July. The post is open to men and women graduates of any university. The stipend will be in the range £800 to £950 a year, plus £60 London allowance and F.S.S.U. benefits if desired. The appointment will be in the first instance probationary for one year and, subject to satisfactory progress, will be continued for at least another two years. Further particulars may be obtained from the Principal.

Applications, which should include a statement of qualifications and the names of not more than three persons to whom reference may be made, should be sent to the Principal, Royal Holloway College, Englefield Green, Surrey, not later than June 24, 1961.

HOUGHTON POULTRY RESEARCH Station invites applications for a Physiologist with research experience. Grading Senior Scientific Officer (£1,302 to £1,654 per annum) or Principal Scientific Officer (£1,666 to £2,418 per annum), according to qualifications and experience. Superannuation under F.S.S.U.—Applications, with names of three referees, to the Station Secretary, Houghton, Huntingdon, before June 24, 1961.

AUSTRALIAN NATIONAL UNIVERSITY
CANBERRA
JOHN CURTIN SCHOOL OF MEDICAL RESEARCH
DEPARTMENT OF MEDICAL CHEMISTRY

Applications are invited from organic chemists for a Research Fellowship in the Department of Medical Chemistry. The successful candidate will work with Professor Adrien Albert or Dr. D. J. Brown on problems in the pyrimidines, pteridines or other hetero-aromatic series. The salary range for Research Fellows is £A.1,625 to £A.2,450 per annum, and appointment is made for three years, with possible extension to the maximum of five years. Reasonable travel expenses will be paid and assistance with housing provided. Superannuation is on the F.S.S.U. pattern.

Further particulars should be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on June 30, 1961.

APPLICATIONS ARE INVITED FOR THE post of Curator of the Coryndon Museum, Nairobi, Kenya. The appointment will be for a period of three years, in the first instance, commencing on July 1, 1961, or as soon after as possible. Candidates should, if possible, have experience in Museum administration as well as general scientific knowledge, especially in biological fields. The post is principally administrative, but will not entail protracted or frequent absence from the Museum buildings. Salary will be in the scale of £2,000 by £60 to £2,540, the point of entry being decided on the basis of previous experience and qualifications. An overseas appointee will receive economy class air passage for himself and wife on taking up the appointment and return passages at the end of three years.—Write in the first instance to: The Secretary, Coryndon Museum, P.O. Box 658, Nairobi, Kenya, East Africa, when further details will be supplied if required.

HOUGHTON POULTRY RESEARCH Station invites applications for two Research Assistants. Both posts superannuable on the Assistant Experimental Officer grade (£625 to £983 per annum); commencing salary according to qualifications, experience and age. Post (1) Assistant Histologist, main Station. Experience in histological techniques essential. Post (2) Research Assistant in Leucosis Experimental Unit including responsibility for supervision of junior technical staff. Experience in tissue culture techniques desirable.—Applications, with names of three referees, to the Station Secretary, Houghton, Huntingdon, before June 24, 1961.

HEAVY ORGANIC CHEMICALS DIVISION

is expanding its

EXPLORATORY RESEARCH GROUP

to study new tonnage chemicals, to develop *new ways* of making them, to establish the *mechanisms* by which they are formed and to work out the *kinetics* of the reactions involved.

Men and women are needed for this

EXPLORATORY RESEARCH TEAM

Organic chemists and physical chemists are needed most, but we should be glad to have a physicist interested in building novel equipment, a first-class mathematician keen on process development techniques, and chemical engineers anxious to work with chemists.

For further information please write to:
Exploratory Research Group Manager,
Imperial Chemical Industries Limited,
Heavy Organic Chemicals Division,
Billingham-on-Tees, Co. Durham,

quoting reference MB/ER/5.

SK&F

wish to appoint

a

BIOCHEMIST

in their

PHARMACOLOGY DEPARTMENT

The post is newly created and the successful applicant will be responsible for the control of all biochemical investigations within the department.

He will be particularly concerned with studies of the actions of new synthetic drugs on metabolic processes with a view to elucidating their mechanisms of action and developing new screening methods for pharmacological activity.

Participation in meetings of scientific societies and publication of results are encouraged.

Previous research experience is essential and the preferred age range is 25-35 years.

An attractive starting salary with annual merit reviews is offered and congenial working conditions in new and well equipped laboratories will be provided.

Other Company benefits include a non-contributory Pension and Life Assurance Scheme, Staff Cafeteria and an active Sports and Social Club.

Under certain circumstances a married man may be eligible for rented unfurnished accommodation and full payment of removal expenses will be made.

Letters of application, giving fullest possible details considered relevant, should be addressed to:

SK&F

The Staff Manager,
SMITH KLINE & FRENCH LABORATORIES LTD.,
Mundells, Welwyn Garden City, Herts.

Please quote Reference No. L.1473.

AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

POST-DOCTORAL FELLOWSHIPS IN PROTEIN CHEMISTRY

The Organization's Division of Protein Chemistry, Melbourne, Victoria, invites applications from graduates in Chemistry or Physics for Post-Doctoral Fellowships. Applicants should have had research experience either in the protein field or with physical or chemical techniques which would find application in this field.

The Fellows selected will join a group of 25 research workers investigating various aspects of protein structure and chemistry. The protein research programme which has been developed by this group over the past twelve years provides an excellent opportunity for gaining experience in this field. A wide range of research equipment for chemical, physico chemical, biophysical and histological studies on proteins is available and a choice of projects relating to both fibrous and globular protein will be offered for selection.

The Fellowships are offered for a period of three years.

SALARY: Commensurate with qualifications and experience; minimum offered £A.1,750 per annum up to a maximum of £A.2,720 per annum. Salary for women will be £A.180 per annum less than corresponding rate for men.

Return fares paid. Further particulars of conditions, etc., supplied on application to: **Mr. E. J. Drake, Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2,**

to whom applications (quoting Appointment No. 462/127), should be addressed by August 19, 1961.

POSTGRADUATE TRAINING for STEEL MILL ENGINEERING

The British Iron and Steel Research Association and The United Steel Companies are offering to honours graduates in engineering or the physical sciences, training in Mill Research and Development, beginning September 1961.

A two-year course of varied training is envisaged, comprising an introductory course on the steel industry and its processes, practical training in the mills of some of the largest steel works in the country and with the principal plant builders, a postgraduate university course in rolling theory and allied subjects and a special project assignment under the guidance of the staff of the leading research and development laboratories in this field.

Depending upon age and qualifications, remuneration will be £800 to £850 per annum during training; afterwards, substantive appointments within the sponsoring organizations will be offered. There is an unsatisfied and rapidly growing demand for men with good theoretical and practical grounding in this field of activity and experience indicates that they are likely to advance rapidly in an industry which offers wide scope, personal satisfaction and substantial emoluments.

Graduates under 26 and those expecting a good honours degree in 1961 are invited to write in the first instance to the

CHIEF DEVELOPMENT ENGINEER (R.&D.D.), The United Steel Companies Ltd., Moorgate, Rotherham

UNIVERSITY OF ABERDEEN

DEPARTMENT OF STATISTICS

Applications are invited for the following posts: Junior Research Fellow for statistical research on Hospital Operation and Design with particular reference to Casualty Department records made available by the Department of Health for Scotland. Salary on scale £800 to £950. Statisticians (consultation and research) for new Research Group in Biometric Medicine. Two or three posts on the following scales: Assistant, £800 to £950; Lecturer, £1,050 to £1,850; Senior Lecturer, £1,850 to £2,425, all with placing according to qualifications and experience.

Further particulars may be obtained from the Secretary, The University, Aberdeen, with whom applications (two copies) should be lodged not later than June 17, 1961.

UNIVERSITY OF SHEFFIELD

DEPARTMENT OF GEOLOGY

Applications are invited for the appointment of a Geochemist with special interest in Spectrography, to begin duties on October 1, 1961. Previous experience of the Geochemistry of Sedimentary rocks is desirable. The work will be carried out in a newly equipped laboratory, and the appointment is a Research post. Salary scale £600 by £50 to £1,000, according to qualifications and experience. Under certain conditions the post may carry F.S.S.U. provision and family allowance. A grant towards removal expenses will be made.

Further particulars may be obtained from the Registrar, to whom applications (four copies), including names and addresses of three referees, should be sent by June 16, 1961.

UNIVERSITY OF BRITISH COLUMBIA

BIOPHYSICIST
METEOROLOGIST

The Physics Department invites inquiries for vacancies at the Assistant Professor rank in (a) Biophysics and (b) Meteorology. In each case the position involves both teaching and research and the potential in these areas will be given greater weight than experience. The appointee will be given an opportunity to initiate his own programme of course work and research. The minimum salary for an Assistant Professor is $7,000. The appointment is required for the Session commencing in September.

Those interested should address their inquiries to: G. M. Shrum, Physics Department, University of British Columbia, Vancouver 8, B.C.

UNIVERSITY OF BRITISH COLUMBIA

LOW TEMPERATURE PHYSICIST

The University invites applications for a vacancy in the Low Temperature Laboratory. The appointment will be made at the rank and salary appropriate to the training and experience of the applicant. The minimum salaries are $7,000 for Assistant Professor, $9,000 for Associate Professor and $12,000 for the rank of Professor. The laboratory is well equipped. The requirements are for a promising young man to take charge and direct a large part of the work.

For fuller information write to: G. M. Shrum, Head, Department of Physics, University of British Columbia, Vancouver 8, B.C.

UNIVERSITY OF MANCHESTER

Applications are invited from graduates in Physics, Chemistry, Metallurgy, Biology or Engineering for the post of Assistant Lecturer in Dental Materials. The person appointed will be concerned with work on the properties of dental materials. Applications would be considered from persons intending to graduate in 1961. There is wide scope for research in this field and ample facilities are available. Salary on a scale £800 to £950 per annum with membership of F.S.S.U. and Children's Allowance Scheme.

Applications should be sent not later than June 3, 1961, to the Registrar, the University, Manchester 13, from whom further particulars and forms of application may be obtained.

MEDICAL RESEARCH COUNCIL

NEUROPHARMACOLOGY RESEARCH UNIT DEPARTMENT OF EXPERIMENTAL PSYCHIATRY, THE MEDICAL SCHOOL, BIRMINGHAM, 15

Applications are invited from graduates and prospective graduates in science to work on a programme of research into the actions of drugs on the central nervous system, using electrophysiological and behavioural techniques. Opportunities for working for a higher degree in the University of Birmingham will be available for those with suitable qualifications.

Applications, in writing, should be addressed to:

Dr. P. B. Bradley,
Neuropharmacology Research Unit,
Department of Experimental Psychiatry,
The Medical School,
Birmingham, 15,

from whom further particulars may be obtained.

McMASTER UNIVERSITY

HAMILTON, ONTARIO

Applications are invited for positions in Physical Chemistry and in Inorganic-Analytical Chemistry for September, 1961, or September, 1962. The appointment will be made at a rank and salary appropriate to qualifications. Preference will be given to recent graduates with postdoctoral experience, and in physical chemistry, to applicants whose research interests lie in the field of radiation and/or nuclear chemistry. The Department has excellent facilities for research including a one-megawatt swimming-pool reactor.

Inquiries should be directed to D. B. MacLean, Chairman, Department of Chemistry.

HOUGHTON POULTRY RESEARCH Station invites applications for a Research Worker in its Leucosis Experimental Unit. Veterinary qualification desirable and postgraduate experience in virology, cyto-pathology or allied fields essential. Grading Senior Scientific Officer (£1,302 to £1,654 per annum); commencing salary according to qualifications and experience. Superannuation under F.S.S.U.—Applications, with names of three referees, to the Station Secretary, Houghton, Huntingdon, before June 24, 1961.

UNIVERSITY OF HONG KONG
SENIOR LECTURESHIP IN CLINICAL PATHOLOGY

Applications are invited for the above-mentioned post. Applicants should be experienced in clinical biochemistry as well as in administration, and be capable of directing the clinical pathology service of a general hospital of approximately six hundred beds. The present salary scales, which are under review, are (including the allowance payable to expatriate staff): £2,250 by £75 to £2,550 (man) or £1,750 by £60 to £1,990 (woman). The equivalent of income tax in the Colony is comparatively low. First-class sea passages are provided for expatriate staff and their families on first appointment and leaves. Accommodation at reasonable rental is provided for those receiving expatriation allowance.

Further particulars and information as to the method of application should be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Hong Kong and London, on July 7, 1961.

UNIVERSITY OF AUCKLAND
NEW ZEALAND
SENIOR LECTURESHIPS OR LECTURESHIPS IN MATHEMATICS

Applications are invited for the above-mentioned appointments (two or more). One lecturer will be required primarily for courses given in the School of Engineering (situated at Ardmore, approximately 20 miles from Auckland) and applicants are requested to state whether they wish to be considered for this post. For the other post special qualifications in any branch of Mathematics may be acceptable, and those in Theory of Statistics will be particularly welcome. The salary scales for the posts are: Senior Lectureships, £1,750 per annum, rising to £2,000 per annum, and Lectureships, £1,250 per annum, rising to £1,700. Commencing salaries within these scales will be determined according to qualifications and experience. An allowance will be made towards travelling expenses.

Further particulars and information as to the method of application should be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in New Zealand and London, on July 3, 1961.

MESSRS. CLARKE, CHAPMAN & CO. LTD.
VICTORIA WORKS, GATESHEAD, 8

Invite applicants for the following position: Computer Programmer. The appointed person, who must hold a good honours degree in mathematics or theoretical physics, will have considerable freedom for work and will be concerned not only with the mechanics of programming (including passage through an electronic machine) but also with associated preparatory mathematical work. Some time will be available for individual research. Excellent staff conditions and progressive salary commensurate with position and in accordance with age and experience.

Please write in first instance to Personnel Officer at the above address. All applications treated in strictest confidence.

ASSISTANT EXPERIMENTAL OFFICERS required by Research Institute (Animal Virus Diseases), Pirbright, Surrey: (1) For Biophysics Department. Work involves application of physical-chemical methods (electron-microscopy, electrophoresis, ultracentrifugation, etc.) to the study of foot-and-mouth disease and other animal virus diseases. Applicants over 22 should have H.N.C. or equivalent. (2) For work connected with production of attenuated strains of foot-and-mouth disease vaccines. Previous experience in virological techniques, preferably including tissue culture, essential. Applicants over 22 should have H.N.C. or F.I.M.L.T., preferably with virology as one subject. Salary dependent on age and qualifications in A.E.O. scale £625 at age 22 rising to £983. Houses available for married applicants. Superannuation scheme.—Applications to Secretary.

INSTITUTE OF CANCER RESEARCH: Royal Cancer Hospital. Technical Assistant required in Physics Department for development of methods of measuring and using in treatment the radiation from linear accelerator and multicurie radioactive sources. G.C.E. "A" level in physics or similar qualification required. Initial salary on M.R.C. scales in range £370 to £860 according to age, qualifications and experience. —Applications, with names of two referees, at least one of whom should be familiar with candidate's recent work, to the Secretary, 33 Sumner Place, S.W.7, quoting ref. 301/B/64.

CYANAMID

CYANAMID OF GREAT BRITAIN LIMITED
Gosport, Hants

invite applications for the following appointments:

(*a*)

FORMULATION CHEMIST/PHARMACIST

for our Development Group.

Candidates should be qualified Pharmacists (preferably B.Pharm. or Ph.D.) who have a special interest in organic chemistry, together with experience of formulation work. The successful applicant will lead a small section investigating a variety of problems associated with Pharmaceutical, Veterinary, Agricultural, and General Chemical formulations. This work will necessitate close liaison with Production Pharmacists and Development Chemists and Microbiologists. Commencing salary in line with age, experience and qualifications.

(*b*)

BACTERIOLOGIST

for our Control Laboratory Group.

Candidates should be Graduates or H.N.C. or A.M.I.L.T. standard, with minimum three years' experience. The duties include Microbiological assays of multi-vitamin preparations, sterility testing of Pharmaceutical, Veterinary and Agricultural products; the successful applicant will also be expected to participate in the investigation of new testing techniques. Commencing salary in line with age, experience and qualifications.

Good employee benefits include an attractive contributory Pension/Life Insurance Scheme.

Suitably detailed applications, indicating present salary, should be forwarded to:

Personnel Officer,
CYANAMID OF GREAT BRITAIN LIMITED,
Fareham Road, Gosport, Hants.

VICTORIA UNIVERSITY OF WELLINGTON
NEW ZEALAND
TWO LECTURERS IN CHEMISTRY

Applications are invited for the above-mentioned appointments. For one of the two positions some preference may be given to applicants who have an interest in teaching first-year students. The salary will be £1,250 per annum, rising by annual increments to £1,700 per annum. The initial salary will be determined according to the qualifications and experience of the appointee. Approved fares to Wellington will be allowed for an appointee, his wife and his dependent children. In addition, actual removal expenses will be allowed within certain limits.

Further particulars and information as to the method of application should be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in New Zealand and London, on June 30, 1961.

SCIENTIFIC POSTS WITH THE LONDON COUNTY COUNCIL

Science undergraduates in their final year, who expect to graduate with an honours degree in chemistry, are invited to apply for appointment as Scientific Officers in the Council's Scientific Branch. Superannuable posts offering a wide variety of work on research, development, and scientific control. £750 to £1,250 with good prospects of promotion (not dependent upon vacancy in the case of a suitable officer) to Senior Scientific Officer (maximum £1,500) and to higher positions. Four weeks paid holiday in addition to public holidays, rising to five weeks after five years service. Four free Saturdays in five. Paid sick leave.

Forms and particulars of the work in the Scientific Branch obtainable from the Medical Officer of Health (D1/N/1393/5), County Hall, S.E.1.

NEW ZEALAND
MARINE DEPARTMENT

Applications are invited for the undermentioned vacancy:

VACANCY NO. 1508: FISHERY BIOLOGIST, WELLINGTON, MARINE DEPARTMENT

An Honours Graduate in Zoology is required to undertake research at the Fisheries Laboratory, Wellington.

Salary will be up to £1,400 a year, according to qualifications and experience. Subsequent promotion is on scientific merit. An outstanding officer might ultimately advance to £2,150.

Qualifications: Applicants should be male, physically fit, and prepared to spend a considerable amount of time in the field or at sea.

Duties: To undertake research on the biology of and factors affecting the production of the principal commercial food fish.

Passages: Steamer fares of up to £172 each for the appointee and his wife, and pro rata for dependent children, will be paid.

Incidental Expenses: Up to £35 for a single person and £100 for a married man can be claimed to cover the cost of taking personal effects to New Zealand.

Application forms and further details are available from the High Commissioner for New Zealand, 415 Strand, London, W.C.2, with whom applications will close on June 22, 1961.

Please quote reference B13/13/1 when inquiring.

INSTITUTE OF CANCER RESEARCH: Royal Cancer Hospital. Chief Technician required for animal houses at Pollards Wood Research Station, Chalfont St. Giles, Bucks. Animal Technological Association diploma or equivalent qualification desirable; also five or more years experience. Salary on M.R.C. scale, £710 to £870 per annum. Possible assistance with housing.—Apply, with names of two referees, to the Secretary, 33 Sumner Place, S.W.7, quoting ref. 301/B/63.

TEA RESEARCH INSTITUTE OF CEYLON

CHEMISTRY OF TEA

Vacancies for:

Heads of Division (2) at £2,000 by £50 to £2,750, tax free.

Tea Research Fellows (2) in U.K. at £1,200 (post-doctorate).

Applications are invited from suitably qualified persons (biochemists, plant physiologists with strong interests in chemistry, organic chemists) for two posts of Head of Division in (a) Plant Biochemistry and (b) Development of Manufacture of tea, tenable in Ceylon; also for two Tea Research Fellowships tenable at suitable research laboratories in the United Kingdom.

The ultimate objective of the work is the improvement of high-grade Ceylon teas, based on increased fundamental knowledge of the growth of the green leaf, of the process of manufacture, and of the desirable properties of made tea.

The well equipped laboratories and the estate are at an altitude of 4,500 ft. above sea level in a climate which does not impede active work; the tea industry in Ceylon is very progressive and finances the Institute generously; provision of assistants will not be limited by finance or space, and an additional laboratory is now being built. The common language is English.

For nationals of Ceylon, India, and Pakistan the salary scale is Rs.740 by Rs.40; Rs.50 to Rs.1,550 per month, plus cost of living allowance of Rs.181/60 for a married officer.

Initial increments may be given; special salary arrangements would certainly be made for an officer with outstanding qualifications as Head of Division. From several countries secondment can be arranged. A free house, with basic furniture, is provided. Overseas paid leave for expatriates after two years or more at the rate of 45 days per year of service, with free passages also for a wife and three children. Provident Fund contributions (15 per cent from each side) may be used partly or wholly to continue existing superannuation arrangements in the officer's home country or to make new ones. The duration of contract is subject to negotiation and may be extensive.

The Tea Research Fellowships are intended initially to last two years. During that time each Fellow will be expected to pay a visit to the Institute in Ceylon, for which funds are provided. The exact subject of research and the University or other laboratory in which it is carried out are for individual arrangement.

Inquiries should be addressed either to Dr. D. I. Gunn, C.B.E., Director, Tea Research Institute, Talawakele, Ceylon, or to Dr. F. R. Tubbs, C.B.E., Director, East Malling Research Station, Maidstone, Kent, England. Definitive applications should be made in duplicate and one sent to Dr. Gunn and one to Dr. Tubbs. Dr. Gunn will be in England in July, 1961, and potential candidates from Europe or the Americas should register their interest before the end of June. Candidates from Australasia would be considered for interview in Ceylon.

NORTHERN REGIONAL HOSPITAL BOARD (SCOTLAND)

Applications are invited from Science Graduates for a post of Non-Medical Assistant Biochemist in the Board's Regional Laboratory Service at the Royal Northern Infirmary, Inverness. The post is in the basic grade and the salary during the probationary period is £650 by £25 (2) to £700 by £30 (4) to £820 by £35 (3) to £925, and after the probationary period £925 by £35 (2) to £995 by £40 (3) to £1,115 by £35 to £1,150.

Further particulars and application forms are obtainable from the undersigned, with whom applications should be lodged by June 5, 1961.

A. M. FRASER, M.D.,
Secretary and
Administrative Medical Officer

Reay House,
17 Old Edinburgh Road, Inverness.

SIR JOHN CASS COLLEGE

JEWRY STREET, LONDON, E.C.3

LECTURER IN GEOGRAPHY

The Governors invite applications from graduate geographers for this newly-established post in the Department of Metallurgy. The successful candidate will be expected to teach some of the subjects forming both Part I and Part II for the B.Sc. (General) Internal degree, and to undertake further research. It will be an added advantage if the candidate has a research qualification and an interest in biogeography, or geomorphology, or meteorology. The salary will be on the scale £1,408 by £35 to £1,601.

Details and form of application, which should be returned as soon as possible, may be obtained from the Secretary.

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING

(UNIVERSITY OF READING)

The Physiology Department requires an honours graduate in chemistry or biochemistry to study the isolation and properties of various enzymes from the mammary gland and milk. The appointment will be for three years, and candidates expecting to graduate this summer will also be considered. Salary in Scientific Officer grade (£717 to £1,222) or Senior Scientific Officer grade (£1,302 to £1,654), according to age and experience; F.S.S.U.

Further information and forms of application may be obtained from the Secretary, N.I.R.D., Shinfield, near Reading, quoting ref. 61/16.

ENGINEERS FOR RESEARCH AND DEVELOPMENT IN GOVERNMENT SERVICE

Following are examples of vacancies at SCIENTIFIC OFFICER (£738 to £1,222) or SENIOR SCIENTIFIC OFFICER (£1,342 to £1,654) level now available:

POST OFFICE RESEARCH STATION, Dollis Hill, London—research into DIRECTIONAL AERIAL SYSTEMS suitable for long distance communications (scientific officer).

NATIONAL PHYSICAL LABORATORY, Teddington, Middlesex—mechanical engineer to lead a small team on HOVERCRAFT research. Practical research experience and knowledge of aerodynamics and hydrodynamics required (senior scientific officer).

ADMIRALTY UNDERWATER WEAPONS ESTABLISHMENT, Portland, Dorset—specialist in THERMODYNAMICS with experience (preferably at least five years) in INTERNAL COMBUSTION ENGINE research or ROCKET PROPULSION. Experience in instrumentation essential (senior scientific officer).

ROYAL RADAR ESTABLISHMENT, Malvern, Worcs—light electrical engineer for research in AIR TRAFFIC DATA HANDLING TECHNIQUES involving data extraction, digital electronic computation and data transmission (scientific officer or senior scientific officer).

There are many other vacancies for RESEARCH and DEVELOPMENT ENGINEERS and most scientific disciplines. All posts carry a pension. Good promotion prospects. Full particulars from Civil Service Commission (Scientific Branch), 17 North Audley Street, London, W.1.

CITY OF PORTSMOUTH COLLEGE OF TECHNOLOGY

DEPARTMENT OF MATHEMATICS AND PHYSICS

RESEARCH ASSISTANT

Applications are invited for the post of Research Assistant. The person appointed will be expected to take part in research work on the microwave properties of certain magnetic oxides and to undertake a certain amount of teaching. The appointment is for three years, and is intended to enable a candidate to prepare for a higher degree. Salary is in the range £650 to £700.

Further particulars and a form of application which should be returned by June 17, may be obtained from the Registrar, College of Technology, Park Road, Portsmouth.

BIRKBECK COLLEGE

(UNIVERSITY OF LONDON)

Applications are invited for the post of Senior Research Assistant in the animal laboratory of the Department of Psychology for work on variables affecting conditioned behaviour. A special interest in pharmacology or physiology would be an advantage. Salary, depending on qualifications, within the range of £850 to £1,100 per annum.

Further particulars should be obtained from the Secretary, Birkbeck College, Malet Street, W.C.1.

NEW ZEALAND METEOROLOGICAL SERVICE

AIR DEPARTMENT

VACANCIES FOR UNIVERSITY GRADUATES

The New Zealand Meteorological Service has immediate vacancies for suitable university graduates wishing to follow professional meteorology as a career in New Zealand.

Qualifications: For preference, applicants should possess a B.Sc. Special degree in Mathematics and/or Physics, but consideration would be given to those with B.Sc. General. Students expecting to complete their degree this year are eligible to apply.

Training: For those without previous experience professional meteorological training will be given in Wellington, New Zealand.

Duties: Appointees, after training, will be engaged on professional meteorological work as considered most appropriate to their individual aptitudes. In general, they will do weather analysis and forecasting, but opportunities are given for concurrent investigational work. In addition, there are interesting openings for suitable specialized officers in research, climatology, agricultural meteorology, instruments, hydrology, etc.

Salary: Minimum starting salaries for appointees with no previous experience are:

B.Sc. General	£745 per annum
B.Sc. Special	£805 " "
B.Sc. Special Second-class honours	£850 " "
B.Sc. Special First-class Honours	£900 " "
Higher qualifications	as applicable

In determination of actual starting salary, credit may be given for any postgraduate scientific work or study. Officers of average ability may rise to £1,700 per annum, and those with exceptional ability to a maximum of £2,300. Salary payments start on taking up duty in New Zealand.

Locations: Initial location for training will be Wellington, New Zealand. Thereafter, officers may serve at one of the forecasting branch offices either in New Zealand or Fiji.

Passages: Steamer fares of up to £172 each for the appointee and his wife, and pro rata for dependent children will be paid.

Incidental Expenses: Up to £35 for a single person and £100 for a married man can be claimed to cover the cost of taking personal effects to New Zealand.

Application forms and further details are available from the High Commissioner for New Zealand, 415 Strand, London, W.C.2, with whom applications will close on June 22, 1961.

Please quote reference B13/3/1 when inquiring.

CENTO INSTITUTE OF NUCLEAR SCIENCE

TEHRAN, IRAN

will have a vacancy for a Physicist with good background in nuclear physics from September, 1961. The appointee will be the only physicist in a group of United Kingdom scientists engaged in fostering the application of radioisotopes in Scientific Institutions and Universities in Iran, Pakistan and Turkey. Duties involve postgraduate teaching, direction of short-term research projects and advisory work. He must have a practical outlook and a particular interest in radioisotope applications. Salary, according to age and experience, would be in the range of £1,440 to £2,590. It would be augmented by a tax-free foreign allowance of about £700 for single men and between £1,120 and £1,335 for married men. Additional tax-free allowances would be payable in respect of children.

Persons interested should complete application forms, which may be obtained from Eastern Department, Room 103, Foreign Office, London, S.W.1. Applications should be received not later than June 20, 1961.

VIROLOGIST

The Scottish Plant Breeding Station requires an Experimental Officer (male) to co-operate in research aimed at developing virus resistance in the potato. The work involves investigations into the inheritance of resistance to virus diseases and the evaluation of progenies by greenhouse tests and field trials. Qualifications: degree in botany or agriculture, with experience of plant virus techniques. Salary scale £1,087 to £1,396, with contributory superannuation scheme.

Applications, giving details of age, qualifications, experience, and names of two referees, to the Secretary, Scottish Plant Breeding Station, Pentlandfield, Roslin, Midlothian, by June 17, 1961.

CITY OF LIVERPOOL EDUCATION COMMITTEE

COLLEGE OF TECHNOLOGY
DEPARTMENT OF PHYSICS AND MATHEMATICS

Applications are invited for the appointment of Research Assistant (temporary), available for a period of two years in the first instance. Duties to commence October 1, 1961, or as soon as possible thereafter. Salary: £645 to £815 per annum (Grade A.P.T.I). The person appointed will be required to participate in a research programme dealing with electron impact and corrosion. An interest in high vacuum techniques and/or electronics will be a recommendation. Applicants should have a degree qualification in physics. Work for a higher degree will be encouraged.

Application form (returnable by June 12, 1961) from the Director of Education, 14 Sir Thomas Street, Liverpool, 1.

THOMAS ALKER,
Town Clerk and Clerk to the
Local Education Authority (J.6818).

MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY

RESEARCH ASSISTANTSHIP IN MATHEMATICS

Applications are invited from honours graduates in physics for a Research Assistantship in the Department of Mathematics. The candidate appointed would be expected to continue and develop a fundamental investigation of the rheological properties of concentrated polymer solutions. Recently developed apparatus is available for the measurement of flow birefringence and normal and shear stress components in shear flow. The work calls for initiative in the design and construction of new apparatus, and for the ability to perform series of observations of sustained accuracy. The appointment will, in the first instance, be for a period of two years at a salary of £675 for the first year, rising to £700 in the second. F.S.S.U. and family allowances.

Applications should be addressed to the Registrar, The Manchester College of Science and Technology, Manchester 1, by Saturday, June 3, 1961.

LONDON HOSPITAL MEDICAL COLLEGE

(UNIVERSITY OF LONDON)
CANCER RESEARCH DEPARTMENT

Applications are invited for the post of Experimental Pathologist in the Cancer Research Department, which is supported by the British Empire Cancer Campaign. Candidates should have had considerable relevant postgraduate experience, and should preferably be in possession of a higher degree. The successful candidate will be required to take an active part in basic research on actiology and experimental transmission of leukaemia. Initial salary not less than £2,000 per annum, together with superannuation and family allowances at the rate of £50 per annum per child.

Applications, together with the names of two referees, to be forwarded in triplicate to the Secretary, The London Hospital Medical College, Turner Street, London, E.1, within fourteen days.

A.R.C. ANIMAL BREEDING RESEARCH ORGANIZATION

Veterinary Surgeon wanted to assist in clinical and experimental investigations of problems of reproduction in farm animals; previous specialist experience not expected. Applications invited particularly from recent or intending graduates. The appointment will be for three years, and payment will be in the Scientific Officer salary scale (£738 to £1,222), according to qualifications and experience. Superannuation F.S.S.U.

Applications should reach the Secretary, 6 South Oswald Road, Edinburgh, 9, not later than July 31, 1961. Further information available on request.

AGRICULTURAL RESEARCH COUNCIL require Isotope Technician at their Institute of Animal Physiology, Babraham, Cambridge. Applicants should be experienced in isotope techniques and the care and servicing of isotope counting equipment. Duties to include helping in the setting up and running of an isotope laboratory and the development of new counting methods. Qualifications: H.N.C., F.I.M.L.T. or equivalent. Appointment in Experimental Officer grade, salary £1,057 to £1,336. Contributory superannuation scheme.—Applications, with names of two referees, to the Secretary of the Institute within three weeks.

BRADFORD INSTITUTE OF TECHNOLOGY

Applications are invited for the posts of: Lecturer in Mathematics, Assistant Grade B in Mathematics. Candidates should possess the qualifications and experience to teach Mathematics for Diploma in Technology courses and for degree courses in Engineering and General Science. Adequate facilities will be given to undertake research, and suitable technical equipment and assistance are available. Salary scale: Lecturer, £1,370 to £1,550 per annum; Assistant Grade B, £700 to £1,150 (plus training and graduate allowances). Previous industrial and research experience at a suitable level will be taken into account in fixing the commencing salary.

Further particulars and forms of application may be obtained from the Registrar (Department F), Bradford Institute of Technology, Bradford, 7.

HENRY PATTEN,
Clerk to the Governors.

CHIEF PHARMACOLOGIST

Fisons Limited are seeking an outstanding man with a wide background of academic training and research experience in Pharmacology and/or Physiology for appointment as Chief Pharmacologist of one of their main operating companies in the pharmaceutical field.

This is an important appointment and if a suitable applicant is forthcoming it is intended to offer him the dual appointment in this company of Deputy Director of Research.

The essential qualities looked for are leadership, enthusiasm and a genuine interest in the discovery and development of new therapeutic agents for man and animals.

Plans for a new Research Block, in very attractive country surroundings, are in an advanced stage but the Chief Pharmacologist will have full opportunity for advising on the layout and equipment of the Pharmacology Section and animal facilities.

Every effort to achieve and maintain a high scientific standard including the publication of original work, will receive full encouragement and support. As Chief Pharmacologist, the person appointed will be primarily responsible for the whole of the pharmacological work carried out by the Research Department. If he is in addition appointed Deputy Director of Research, he will assist in planning, co-ordinating, and executing a research programme, involving Organic Chemists, Biochemists, and Microbiologists, as well as Pharmacologists.

An outstanding salary will be paid to an outstanding man. Contributory pension schemes for retirement pension and for pensions to widows and children in the event of employees dying before retirement, are in operation.

All applications or letters of enquiry will be dealt with in strict confidence, and should be sent to the Managing Director (Ref. C.P.), Fisons Limited, Fison House, 95 Wigmore Street, London, W.1.

QUEEN MARY COLLEGE

(UNIVERSITY OF LONDON)

Applications are invited for a Research Fellowship in Nuclear Physics Group of the Department of Physics. To prepare and participate in experiments on the 7 GeV. proton synchrotron at the Rutherford High Energy Laboratory of the National Institute for Research in Nuclear Science. Period of appointment from October 1, 1961, for two years, with possibility of renewal for a further year. Salary £900 by £50, with F.S.S.U.

Application forms, obtainable from the Registrar, Queen Mary College, Mile End Road, E.1, to be returned by June 9.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

Applications are invited for a Postdoctoral Fellowship, tenable for two years, for work in the field of Photochemical Reactions in the Alkali Halides. Stipend: £900 per annum, plus F.S.S.U.

Applications, giving details of qualifications and names of two referees, should be sent as soon as possible to Dr. P. W. M. Jacobs, Chemistry Department, Imperial College, London, S.W.7.

MACAULAY INSTITUTE FOR SOIL RESEARCH

Applications are invited from graduates with first- or second-class honours in Mathematics with Statistics, or a Diploma in Statistics, for a vacancy in the Statistics Section. The duties are mainly concerned with the design and analysis of field experiments. The appointment will be made in the Scientific Officer Grade, starting salary within the range £738 to £1,222 per annum, according to age, qualifications and experience. Superannuation Scheme.

Forms of application may be obtained from the Secretary, the Macaulay Institute for Soil Research, Craigiebuckler, Aberdeen, to whom they should be returned before June 10, 1961.

UNIVERSITY OF BRISTOL

DEPARTMENT OF ORGANIC CHEMISTRY

Applications are invited for the post of Lecturer (Grade II) within the salary scale £1,050 by £50 to £1,400 by £75 to £1,475 (bar); £1,550 by £75 to £1,850 per annum. The initial salary will be at a point in the scale below the bar. The post involves teaching duties at undergraduate and postgraduate levels, and the Lecturer appointed will be expected to engage in research for which full facilities are provided. Superannuation under the F.S.S.U. Scheme and Family Allowances.

Further particulars may be obtained from the Registrar, the University, Bristol 8, to whom applications, giving the names of two or three referees, should be sent by June 5.

UNIVERSITY OF OTAGO

NEW ZEALAND
LECTURER IN MATHEMATICS

Applications are invited for this position. Salary range £1,250 to £1,700 per annum.

Further particulars and information as to the method of application are available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, or from the Registrar, the University of Otago, Dunedin, New Zealand. Applications close, in New Zealand and London, on July 15, 1961.

UNIVERSITY OF OTAGO

NEW ZEALAND
SENIOR LECTURER OR LECTURER IN PHYSICS

Applications are invited for this position. It is hoped to make the appointment at the Lecturer level (salary £1,250 by £75 to £1,700 per annum) but an appointment would be possible at the Senior Lecturer level (salary £1,750 to £2,000 per annum) if a suitably qualified applicant was available.

Further particulars are available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, or from the Registrar, University of Otago, Dunedin, New Zealand. Applications close, in New Zealand and London, on July 15, 1961.

UNIVERSITY COLLEGE

IBADAN, NIGERIA

Applications are invited for Lectureship in Plant Breeding in Department of Agriculture. Knowledge of selection and breeding of Nigerian grasses essential. Appointment to commence as soon as possible. Salary scale: £1,200 by £75 to £1,650 (bar); £1,725 by £75 to £2,175 per annum. Passages paid for appointee, wife and up to five children under 11 years, on appointment, annual overseas leave and termination. F.S.S.U. Children's, car and outfit allowances. Part-furnished accommodation at rent not exceeding 7.7 per cent of salary.

Detailed applications (six copies), naming three referees, by June 25, 1961, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

UNIVERSITY OF GLASGOW

LECTURESHIP OR ASSISTANTSHIP IN GEOLOGY

Applications are invited for a Lectureship or an Assistantship in Geology. Salary scale: £1,050 to £1,850 per annum for Lecturers, and £800 to £950 per annum for Assistants. Initial salary according to experience and qualifications. F.S.S.U. and family allowance benefits.

Applications (eight copies for the Lectureship, three copies for the Assistantship) should be lodged, not later than June 10, 1961, with the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court.

UNIVERSITY OF ST. ANDREWS

LECTURER IN RADIATION PHYSICS AND BIOLOGY

Applications are invited for the above post in the Isotopes Laboratory, Queen's College, Dundee. The work will be concerned with the provision of courses in Radiation Physics and Biology, and with implementing a code of practice for the protection of persons exposed to ionizing radiations throughout the University. The Isotopes Laboratory is concerned mainly with pure research in the Medical and Physical Sciences and the successful candidate will have good facilities for research. Salary: £1,050 by £50 to £1,400 (efficiency bar) by £75 to £1,850. F.S.S.U.. Family allowance. Grant towards furniture removal expenses.

Applications are invited from Physicists or Physical Chemists with some background in the biological sciences. Six copies of the application containing the names of three referees to the undernoted, not later than June 17, 1961.

PATRICK CUMMING,
Joint Clerk to the University Court.
Queen's College, Dundee.

UNIVERSITY OF LONDON KING'S COLLEGE

The College will require from October 1, 1961, an Assistant Lecturer in the Geology Department to teach Mineralogy and encourage research in this field. Salary scale: £800 by £50 per annum to £950. A London allowance of £60, family allowances, and F.S.S.U. benefits will also be payable.

Conditions of appointment and application forms may be obtained from the Registrar, King's College London, Strand, W.C.2.; completed forms must reach him by June 16.

BRADFORD INSTITUTE OF TECHNOLOGY

DEPARTMENT OF BIOLOGICAL SCIENCES

Applications are invited for the post of Reader in Biology. Candidates should possess high academic qualifications and have had considerable teaching and research experience in any field of Botany or Zoology. Consultative work is encouraged and fees paid for such work may be retained. Salary scale: £1,800 by £50 to £2,100 per annum (or above in special cases). Previous industrial or research experience at a suitable level will be taken into account in fixing the commencing salary.

Further particulars and forms of application may be obtained from the Registrar (Department F), Bradford Institute of Technology, Bradford, 7.

HENRY PATTEN,
Clerk to the Governors.

UNIVERSITY OF DURHAM

KING'S COLLEGE, NEWCASTLE UPON TYNE

Research Worker required in Glaciology, initially for two years at £800 per annum.

Applications, including names of two referees, should reach Dr. Hal Lister, Lecturer in Polar Studies, King's College, Newcastle upon Tyne, 1, before June 8, 1961.

PADDINGTON GENERAL HOSPITAL

DEPARTMENT OF PATHOLOGY
HARROW ROAD, W.9

Vacancy for Technician in Biochemistry. Whitley Council conditions of service. Holders of B.Sc. or A.R.I.C. considered.

Apply to Director, Telephone Cunningham 4884, Extension 337.

HOUGHTON POULTRY RESEARCH Station invites applications for a Biochemist with research experience. Grading Scientific Officer (£717 to £1,222 per annum) or Senior Scientific Officer (£1,302 to £1,654 per annum) according to qualifications and experience. Superannuation under F.S.S.U.—Applications, with names of three referees, to the Station Secretary, Houghton, Huntingdon, before June 24, 1961.

GLASS-MINDED ENGINEER required with commercial knowledge. Able to follow projects in Chemical and Pharmaceutical Industries. Permanent and progressive position.—Applicants should submit details of education and career to date to Box 966, T. G. Scott & Son, Ltd., 1 Clement's Inn, London, W.C.2.

UNIVERSITY OF BIRMINGHAM

DEPARTMENT OF PHYSICAL METALLURGY

Applications are invited for the post of Lecturer in Physical Metallurgy (£1,050 by £50 to £1,400 by £75 to £1,550; £1,550 by £75 to £1,850) or Assistant Lecturer (£850 by £50 to £950). Initial stipend according to qualifications and experience. The successful candidate will take responsibility for lecture courses in general physical metallurgy, and research under the general direction of the Head of the Department. Some research experience is desirable, but not essential. Appointment, which is tenable from October 1, 1961, carries F.S.S.U., and family allowance benefits.

Applications (three copies), naming three referees, should be sent by July 1, 1961, to the Assistant Registrar (Science), the University, Edgbaston, Birmingham, 15, from whom further particulars may be obtained.

UNIVERSITY OF EXETER

Applications for the post of Research Assistant for work on volatile inorganic compounds in collaboration with Dr. L. H. Long, are invited from chemists preferably with two or three years' research experience. Salary £850 per annum, plus F.S.S.U. benefits.

Applications, giving a brief account of career and nominating two referees, should reach the Secretary of the University by June 17.

CONNAUGHT HOSPITAL

DEPARTMENT OF PATHOLOGY
WALTHAMSTOW, E.17

Junior Technician and Student Technician required. Facilities for training and study for the examinations of the I.M.L.T. Salary in accordance with Whitley Scales.

Forms of application may be obtained from Secretary, Forest Group H.M.C., Langthorne Road, E.11.

UNIVERSITY OF MANCHESTER

Applications are invited from graduates in Chemistry or Biochemistry for the post of Research Assistant in Chemistry under the auspices of the British Empire Cancer Campaign Committee to work in the Department of Chemistry of the Faculty of Science under the direction of Dr. G. R. Barker, on the chemistry and biochemistry of nucleic acids. It is expected that the person appointed would use the work towards obtaining a higher degree. Applications from persons intending to graduate this summer would also be considered. Salary would be £350 per annum. The person appointed would be required to take up duties on October 1, 1961.

Applications should be sent not later than June 17, 1961, to the Registrar, The University, Manchester, 13, from whom further particulars and forms of application may be obtained.

UNIVERSITY OF SHEFFIELD

Applications are invited for the post of Temporary Assistant Lecturer in Geology, to begin duties on October 1, 1961. A candidate should have special interest in Palaeontology and Stratigraphy. The appointment will be for one year only for the Session 1961-62. Initial salary according to qualifications and experience on the scale £800 by £50 to £950, with family allowance.

Further particulars may be obtained from the Registrar, to whom applications (four copies), including the names and addresses of three referees, should be sent by June 16, 1961.

ORGANIC CHEMISTS WHO HAVE RECently obtained or expect their higher degrees are invited to apply for positions in small teams engaged on synthetic organic chemistry in close co-operation with pharmacologists. Our new laboratories, pleasantly situated in rural surroundings, are well equipped to carry out a programme of research upon new compounds of potential therapeutic value—Please write, with details of education and research experience, to the Research Director, Miles Laboratories Ltd., Stoke Court, Stoke Poges, Buckinghamshire.

ASSISTANT EXPERIMENTAL OFFICERS required at the National Vegetable Research Station, Wellesbourne, Warwick, for the following sections: Physiology: for growth and development studies on vegetable crops. Plant Breeding: to assist in breeding programmes and to do cytological checks on breeding material. Qualifications: degree (science or horticulture) or equivalent. Salary in scale £578 per annum at age 21 to £983. Contributory superannuation scheme.—Applications, with names and addresses of two referees, to Secretary by June 10, 1961.

GALLENKAMP

YOUNG MEN with imagination required in expanding organisation for development of Scientific Equipment. Graduate or similar qualification in Science or Instrument Technology preferred.

Starting salary according to age, qualifications and experience. Pension Scheme. Five-day week.

Apply Technical Director:
A. GALLENKAMP & CO. LTD.,
Sun Street, London, E.C.2.

WEST OF SCOTLAND AGRICULTURAL COLLEGE

Applications are invited for a post of Lecturer in Botany from Graduates in Science with special qualifications in Botany or Agricultural Botany (although intending Graduates are not debarred from applying). The salary scale, which will depend on the age, qualifications and experience of the successful applicant, will be on one or other of the following grades: Grade III (Provincial) £975 rising to £1,570. Grade IV (Provincial) £698 (honours graduates £717) rising to £993.

Conditions of appointment and application forms are obtainable from the Secretary, 6 Blythswood Square, Glasgow, C.2, with whom applications should be lodged not later than June 17, 1961.

McMASTER UNIVERSITY

POST-DOCTORAL FELLOWSHIPS IN CHEMISTRY

Applications are invited for post-doctoral Teaching and Research Fellowships tenable in the Department of Chemistry. These awards are worth $5,500 per annum and approximately one-third of the candidate's time will be devoted to teaching duties.

Applications, with curriculum vitae and names of two referees, should be sent promptly to D. B. MacLean, Chairman, Department of Chemistry, McMaster University, Hamilton, Ontario, Canada.

BIRKBECK COLLEGE

(UNIVERSITY OF LONDON)

Postgraduate Research Assistant required for studies of liquid structure under the personal supervision of Professor J. D. Bernal. Knowledge of X-ray diffraction methods essential. Salary according to qualifications and experience within the range £700 to £900 per annum.

Applications to the Secretary, Birkbeck College, Malet Street, W.C.1.

UNIVERSITY OF SOUTHAMPTON

Postdoctoral Research Fellowship available for research in gas kinetics for two years from September/October, 1961. Salary £850 per annum, plus F.S.S.U.

Applications, giving age, qualifications and experience, to Dr. H. M. Frey, Chemistry Department, The University, Southampton.

ROWETT RESEARCH INSTITUTE

Statistician required for temporary A.R.C. appointment for one year in the first instance. Salary within the Scientific Officer, £717 to £1,186 or Senior Scientific Officer, £1,302 to £1,604 range, according to experience.

Applications, stating date of birth, with particulars of qualifications and experience, should be sent to the Secretary, Rowett Research Institute, Bucksburn, Aberdeen.

A PATENTS AND INFORMATION OFFIcer. A company engaged on the large-scale manufacture of synthetic resins and adhesives requires a Patents and Information Officer who would be responsible for the preparation, filing, registration and interpretation of patents and the preparation of a company technical information bulletin. Applicants should be chemical graduates aged between 25 and 30 years and possessing a good knowledge of German. Previous experience in either the patents or information fields would be advantageous. Three months' training in patent work will be given at the parent company in Basle, Switzerland. Salary will depend on age, experience and qualifications, and there is a good contributory pension scheme.—Applications, giving age, present salary and details of career to date, should be sent in confidence to the Personnel Manager, CIBA (A.R.L.) Limited, Duxford, Cambridge.

DAIRY SCIENCE AND SCIENCE GRADUATES

required by

AN FORAS TALUNTAIS (The Agricultural Institute) for Research in Dairy Technology, Chemistry, and Bacteriology under its Animal Production Division at the Dairying Research Centre, Moorepark, Fermoy. In each case rating and salary in accordance with qualifications and experience. Marriage and children's allowances. Superannuation Scheme.

(1) **Dairy Technology.** Grade—up to and including Principal Research Officer. ESSENTIAL: (i) Good Honours Degree in Dairy Science or Science. (ii) Experience of research in this field and of organizing research.

(2) **Dairy Chemistry.** Grade—up to and including Senior Research Officer. ESSENTIAL: Honours Degree in Science (majoring in Chemistry or Bio-Chemistry).

(3) **Dairy Bacteriology.** Grade—up to and including Senior Research Officer. ESSENTIAL: Honours Degree in Science (majoring in Bacteriology).

Further particulars and application forms from Director, An Foras Talúntais, 33 Merrion Road, Dublin, 4. Latest date for receipt of completed forms June 12, 1961.

HUDDERSFIELD COLLEGE OF TECHNOLOGY

Principal: Dr. W. E. Scott, M.B.E.

HEADSHIP OF DEPARTMENT OF MATHEMATICS

Applications are invited for the HEADSHIP of the Department of MATHEMATICS. Applicants should possess high academic qualifications in Mathematics with teaching and research or industrial experience. Specialization in statistics and/or numerical analysis would be an advantage.

Salary (Burnham Scale) Grade III, £1,800 per annum by £50 per annum to £1,950 per annum. The starting salary within this range is determined in the light of previous experience.

Forms of application and further particulars obtainable from the Principal, to whom applications should be returned as soon as possible.

H. GRAY,
Clerk to the Governors.

UNIVERSITY COLLEGE, DUBLIN

PROFESSORSHIP OF BOTANY

Applications are invited by the Governing Body of University College, Dublin, for the above Statutory Office. Applicants must forward to the Secretary and Bursar, University College, Dublin, 150 copies of their applications and testimonials to be received by him not later than June 17, 1961.

Further particulars may be obtained from

J. P. MacHALE,
Secretary and Bursar.

University College,
Earlsfort Terrace,
Dublin.

INSTITUTE OF CHILD HEALTH

(UNIVERSITY OF LONDON)

Applications are invited for the post of Lecturer in Paediatrics based at the Queen Elizabeth Hospital for Children, Hackney Road, E.2. The successful applicant will be required to undertake clinical work, the co-ordination of postgraduate teaching and clinical or pathological research. Salary will be within the scale £1,350 to £2,200 per annum.

Applications, including the names of three referees, should be addressed to the Secretary, Institute of Child Health, Great Ormond Street, W.C.1, to arrive by June 30, 1961.

WRIGHT-FLEMING INSTITUTE OF Microbiology, St. Mary's Hospital Medical School, invites applications from medical or science graduates for the Pfizer Fellowship. The Fellow will be expected to work for a higher degree in some aspect of the microbiology of infective disease. The Fellowship is tenable for one year in the first instance commencing October 1, 1961, with the possibility of extension. Stipend in the range £650 to £850 per annum according to age and experience.—Apply to the Secretary, Wright-Fleming Institute of Microbiology, St. Mary's Hospital Medical School, Paddington, London, W.2, before June 30, 1961.

IMPERIAL CANCER RESEARCH FUND

THREE RESEARCH ASSISTANTS REQUIRED IN DIVISION OF PATHOLOGY

Graduates in medicine or biology interested in histology, cytology, cytochemistry, morbid anatomy, or experimental pathology. Some experience desirable but not essential. Appointment initially for three years. Salaries within range £850 to £1,625 per annum, depending upon qualifications and experience, plus London allowance, F.S.S.U., and children's allowances.

Applications (three copies), with names of three referees, to the Secretary, Imperial Cancer Research Fund, Lincoln's Inn Fields, London W.C.2, before July 1, 1961.

UNIVERSITY COLLEGE LONDON

DEPARTMENT OF ZOOLOGY

Applications are invited for post of Assistant Lecturer. Duties will begin October 1, 1961, or by arrangement. Salary within range £800 to £950, plus £60 London allowance, per annum, according to qualifications and experience. F.S.S.U. and family allowance. Preference will be given to candidates working in the field of insect physiology.

Applications, to be received by July 10, 1961, should be sent to the Secretary, from whom further particulars may be obtained.

UNIVERSITY OF ABERDEEN

DEPARTMENT OF PHYSIOLOGY

Applications are invited for post of Lecturer. Salary if medically qualified on scale £1,050 to £2,100, otherwise on scale £1,050 to £1,850. Superannuation, child allowance, and removal allowance. Appointment from October 1, 1961, or date to be arranged.

Further particulars may be obtained from the Secretary, The University, Aberdeen, with whom applications (eight copies) should be lodged not later than June 18, 1961.

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

ASSISTANT LIBRARIANS

are required at the

ATOMIC ENERGY RESEARCH ESTABLISHMENT, HARWELL (POST A)

and the

CULHAM LABORATORY, near ABINGDON, BERKS (POST B)

POST A: to take charge of the Cataloguing and Ordering Department which deals with all the Library intake of literature (published and report), and to be responsible for production of four accessions lists and a monthly list of the Authority's publications available to the public.

SALARY in the range £1,165 per annum to £1,430 per annum according to experience.

POST B: to be responsible to the Librarian for:

(a) Day to day supervision of the loan, reference and enquiry service.

(b) Ordering, accessioning and cataloguing additional material. Some translation work will be required.

SALARY: £495 (at age 18) to £1,055 per annum or in the range £1,165 per annum to £1,430 per annum according to experience.

Applicants for both posts should be Fellows or Associates of the Library Association and have had experience in a Scientific or technical library which should include:

POST A—Cataloguing and classification preferably by U.D.C. and staff organization.

POST B—Document reproduction techniques. Ability to translate from one or two foreign languages, particularly German and/or Russian would be an advantage.

Superannuation scheme. A house, or house purchase assistance provided.

Send postcard for details to Personnel Manager (1955/34), U.K.A.E.A., A.E.R.E., Harwell, Didcot, Berks.

HERIOT-WATT COLLEGE

EDINBURGH

Applications are invited for the following LECTURESHIPS commencing on September 1, 1961, or as soon as possible thereafter:

INORGANIC CHEMISTRY
PHYSICS
MATHEMATICS

Candidates should hold an honours degree or equivalent qualification. Previous teaching experience is desirable. Industrial and/or research experience will be regarded as additional qualification.

Candidates may be placed, according to qualifications and experience, either on the Salary Scale for Lecturers Grade I, viz., £1,050 to £1,700, or on Grade II(a)—£900 to £1,550.

Further particulars may be obtained from the Principal to whom applications must be submitted not later than June 10.

HAREFIELD HOSPITAL

HAREFIELD, MIDDLESEX

(610 beds: General and Chest)

Senior Biochemist required. Salary scale £1,250 to £1,700 per annum, plus £50 London weighting. Candidates should normally have had at least five years experience in the basic grade.

Applications, quoting two referees, to reach Group Secretary, Harefield and Northwood Group H.M.C., Mount Vernon Hospital, Northwood, Middlesex, by June 6, 1961.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

Engineering or Science Graduates required for research into problems in fluid mechanics and oil combustion. Results should be suitable for higher degrees. Grants up to £500 per annum.

Applications to R. P. Fraser, O.B.E., Chemical Engineering Department, Imperial College, London, S.W.7.

UNIVERSITY COLLEGE OF WALES

ABERYSTWYTH

Applications are invited for the post of Assistant Lecturer in Biochemistry in the Department of Agricultural Biochemistry to begin duties on October 1, 1961.

Applications should be sent not later than June 24, 1961, to the Registrar, from whom further particulars and forms of application can be obtained.

THE MEDICAL RESEARCH COUNCIL requires a Research Assistant with a good honours degree in biochemistry to study the factors influencing the renal excretion of calcium in man. The appointment is for three years in the first instance, and opportunities are available to register for a higher degree. Starting salary within the range £750 to £850 per annum.—Applications, with names of two referees, to Dr. A. Hodgkinson, Metabolic Disturbances in Surgery Research Unit, The General Infirmary, Leeds, 1.

VETERINARY OFFICERS, RESEARCH Officers, Assistant Veterinary Investigation Officers: Ministry of Agriculture, Fisheries and Food. Pensionable posts for men and women aged at least 23. M.R.C.V.S. normally required, and postgraduate experience desirable. Present vacancies for Research Officers in virology, pathology, bacteriology, and biochemistry. National salary scales: £926 (at 23) to £1,269 (at 32 or over), rising to £1,420, then to £1,778. Promotion prospects.—Write Civil Service Commission, Burlington Gardens, London, W.1, for application form, quoting **130-173-265/61.** Early application advised.

RESEARCH BIOCHEMIST FOR EXPANDing Company near Windsor, to establish Control Laboratory for Enzymes and Biochemicals using modern I.R. and U.V. techniques. He would also be provided with all facilities for investigating new and unusual biochemicals. Publications encouraged. He should hold a University degree with two or three years' postgraduate or research experience in Biochemistry. Five-day week, Pension Scheme. Salary around £1,500.—Apply Box 967, T. G. Scott & Son, Ltd., 1 Clement's Inn London, W.C.2.

AUSTRALIA

THE UNIVERSITY OF NEW SOUTH WALES STAFF APPOINTMENTS—SCHOOL OF PHYSICS

The University of New South Wales wishes to appoint academic staff to the School of Physics.

The School offers courses to students taking physics at the B.Sc. and honours levels, and also to those undertaking research work for the degree of M.Sc. and Ph.D., in the Faculty of Science. Physics is also taught to first- and second-year students in other Faculties.

The School is active in research, particularly in the fields of solar-furnace high-temperature studies, N.M.R., acoustics, and gas-discharge physics, and in aspects of solid-state physics, including X-ray crystallography, dielectric breakdown, low-energy electron diffraction, and vacuum-ultra-violet studies of surfaces.

Facilities for research work of staff and post-graduate students are good. There are well-equipped mechanical, electrical, and optical workshops, and the University has a large electronic digital computer (UTECOM, an English Electric DEUCE machine).

Inquiries about the School of Physics may be addressed to the Head of the School, Professor C. J. Milner.

For appointment as Senior Lecturer, applicants must have a higher degree or equivalent qualifications.

Applicants for the position of Lecturer must have a degree with honours in physics.

Salary: Senior Lecturer, £A.2,592 range £A.3,042 per annum; Lecturer, £A.1,772 range £A.2,477 per annum.

Commencing salaries for these positions are determined by qualifications and experience.

Successful applicants will be eligible, subject to passing a medical examination, to contribute to the State Superannuation Fund.

First-class ship fares to Sydney of appointees and their families will be paid.

Four copies of applications (including the names of two referees) should be lodged with the Agent General for New South Wales, 56-57 Strand, London, W.C.2, and a copy forwarded to the Appointments Section, The University of New South Wales, Box 1, Post Office, Kensington, N.S.W., Australia, by airmail, to arrive before July 14, 1961. Applicants outside the United Kingdom and Eire need only submit one copy of their application to the London address in addition to the copy sent to Sydney.

UNIVERSITY OF OTTAWA

OTTAWA, ONTARIO, CANADA

Assistant Professor in Pharmacology required. Ph.D. or M.B. Salary $6,000 to $8,500, according to qualifications and experience.

Applications to Professor M. F. Murnaghan at the above address.

U.S.A.

CREIGHTON UNIVERSITY SCHOOL OF MEDICINE

One year Visiting Lectureship in Anatomy. To participate in teaching of Gross Anatomy to medical and dental students September, 1961, to June, 1962. Salary: $7,000, plus passage.

Please send curriculum vitae to Dr. William T. Niemer, Department of Anatomy, The Creighton University School of Medicine, 302 North 14th Street, Omaha 2, Nebraska, U.S.A.

UNIVERSITY OF MANCHESTER

Applications are invited for the post of Assistant Lecturer in Organic Chemistry. Salary on a scale £800 to £950 per annum with membership of the F.S.S.U. and Children's Allowance Scheme.

Applications should be sent not later than June 5, 1961, to the Registrar, the University, Manchester, 13, from whom further particulars and forms of application may be obtained.

THE BRITISH NON-FERROUS METALS Research Association is further strengthening its specialized information service and invites applications from graduates in metallurgy, physics or chemistry who have some experience in information work. Appointments carrying salaries commensurate with the experience required and the responsibilities borne are to be filled.—Apply Secretary, B.N.F.M.R.A., Euston Street, London, N.W.1.

RADIATION PHYSICIST: FACULTY APpointment. Teach radiation physics, supervise radiation health programme and conduct own research. Electronic Engineer: Faculty appointment. Conduct own research and consult in biomedical problems, supervise a modern electronics shop.—Professor Charles D. Kochakian, Coordinator Research University of Alabama Medical Center, Birmingham 3, Alabama.

KENT EDUCATION COMMITTEE

MEDWAY COLLEGE OF TECHNOLOGY RESEARCH ASSISTANTSHIP IN CHEMISTRY

Applications are invited for appointment to a Research Assistantship or Research Studentship in Chemistry from candidates who hold an Honours degree of a British university, or who are Graduate Members or Associates of the Royal Institute of Chemistry and are qualified to work for a higher degree or research diploma. Students taking finals this summer are eligible for consideration.

The successful candidate will be required to undertake full-time research in one of the following fields: synthetic or physical or organic chemistry, molecular spectroscopy, thermodynamics, electrochemistry, surface chemistry, or biochemistry and will have the opportunity of teaching for not more than six hours per week.

Applications, naming two referees and giving full details of qualifications and previous experience, should be sent to the Principal, Medway College of Technology, Horsted, Maidstone Road, Chatham, Kent, from whom further details may be obtained.

CHEMIST OR PHYSICIST

graduate or equivalent qualification, required for the research laboratory of a North Midlands paper mill making high grade specialities. Age about 21 to 28; previous papermaking or research experience useful but not essential.

This appointment in a steadily expanding department offers interesting opportunities to a man of wide interests yet practical outlook; it carries a good salary and other benefits.

Applications, giving full details, which will be treated in confidence, should be addressed to Personnel Director, Brittains Limited, Cheddleton Paper Mills, Leek, Staffs.

UNIVERSITY OF GLASGOW

LECTURESHIP IN BIOCHEMISTRY

Applications are invited for a Lectureship in Biochemistry. Salary scale: with a medical qualification, £1,050 to £1,900 per annum; without a medical qualification, £1,050 to £1,850 per annum. Initial salary according to experience and qualifications. F.S.S.U. and family allowance benefits.

Applications (eight copies) should be lodged, not later than June 16, 1961, with the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court.

UNIVERSITY OF GLASGOW

ELECTRONIC DEVELOPMENT ENGINEER

A vacancy exists for an ENGINEER interested in developing electronic equipment for research and teaching. Candidates should preferably have had experience of this type of work, and should have an appropriate Higher National Certificate or similar qualification.

Well-equipped workshops and laboratories in a new building provide excellent working conditions.

Starting salary in the range £700 to £950 per annum, depending on experience and qualifications.

Applications, with brief details of career and qualifications, should be sent to the Secretary of the University Court, The University, Glasgow, W.2, not later than June 3, 1961.

UNIVERSITY COLLEGE OF NORTH STAFFORDSHIRE

Applications are invited for the post of Demonstrator in Biology Department. Candidates should have a good honours degree in biology or zoology, and preference will be given to those with experience in practical genetics. Salary £550 per annum.

Application forms and further particulars can be obtained from the Registrar, The College, Keele, Staffs, to whom completed forms should be returned not later than June 15, 1961.

TECHNICIAN (FEMALE) REQUIRED FOR new expanding Physics Laboratory. Salary at minimum age 21 £570 rising to £710. Qualifications G.C.E. "A" level in physics and mathematics, or similar. Work chiefly concerned with diagnosis and treatment using radioactive isotopes.

Further particulars may be obtained from Hospital Secretary, Dudley Road Hospital, Birmingham, 18.

UNIVERSITY OF BRISTOL

Applications are invited for the post of Lecturer (Grade II) in Physics tenable from October 1, 1961. Salary scale: £1,050 by £50 to £1,400 by £75 to £1,475 (bar); £1,475 by £75 to £1,850. Preference will be given to candidates having special interests in elementary particles or solid state physics.

Full particulars may be obtained from the Registrar, University, Bristol 8, to whom applications should be sent by June 9.

NORTH LONDON BLOOD TRANSFUSION CENTRE

DEANSBROOK ROAD, EDGWARE, MIDDLESEX

Medical Laboratory Technician required, qualified A.I.M.L.T., science degree or equivalent. Present commencing salary £595, rising to £720, plus London weighting £20 or £30. Whitley conditions.

Applications in writing as soon as possible to the Administrative Officer.

APPLICATIONS ARE INVITED FOR A post as Professor of Organic Chemistry which has been created because of the continued expansion of the Department. Minimum salary $12,000 per annum. Candidates should send their applications (which should include the names of three referees) immediately to Professor C. A. McDowell, Department of Chemistry, University of British Columbia, Vancouver 8, B.C., Canada, from whom further particulars may be obtained.—Interviews may be arranged in London between June 26 and July 25, 1961, by writing to Professor C. A. McDowell, c/o British Columbia House, Regent Street, London, W.1, during the above period.

GLASSHOUSE CROPS RESEARCH INSTITUTE. Head of Mycology and Bacteriology Department. Applications invited for this post, which will fall vacant on October 1, 1961, on retirement of present holder. Candidates should have wide experience of research on plant diseases caused by fungi and bacteria; a special interest in microbiological problems, e.g., as associated with soil or mushroom composts, would be an advantage. Appointment in Principal Scientific Officer grade, £1,666 (£1,716 on January 1, 1962) to £2,418.—Further details available from Secretary to the Institute, Worthing Road, Rustington, Littlehampton, Sussex, to whom applications, with names of three referees, should be submitted before June 30, 1961.

GRADUATE IN A BIOLOGICAL SCIENCE with an interest in cytogenetics required to work as a Research Assistant in the Cytogenetics Section of this Unit. Applications will be considered from undergraduates about to write their final examinations. Salary according to age and experience within the Medical Research Council scales.—Applications, giving full details of career, together with the names of two referees, should be sent to the Administrator, Radiobiological Research Unit, Medical Research Council, Harwell, Berks, by June 19.

BIOCHEMISTS: B.SC. OR PH.D. REQUIRED for work on the mechanism of androgen action in protein and nucleic acid synthesis. Opportunity for advancement. Graduate work permitted for B.Sc. appointee.—Professor Charles D. Kochakian, University of Alabama Medical Center, Birmingham 3, Alabama.

TULLIS RUSSELL & CO. LTD. REQUIRE the services of a Laboratory Manager. Qualifications should include a good degree in science and considerable experience of laboratory organization, preferably but not necessarily, in the paper industry.—Applications to the Chief Chemist, Tullis Russell & Co. Ltd., Auchmuty & Rothes Paper Mills, Markinch, Fife.

LECTURES AND COURSES

UNIVERSITY COLLEGE LONDON

GOWER STREET, LONDON, W.C.1

FREE PUBLIC LECTURES, SUMMER TERM 1961

Tuesday, June 6, at 5.30. "Bradykinin—its Chemistry, Pharmacology, and Role in Physiological and Pathological Reactions," by Dr. G. P. Lewis.

Monday, June 26, at 5, "Propionic Acid Metabolism in Animal Tissues," by Dr. Severo Ochoa.

GRESHAM LECTURES. DR. W. H. Steavenson, F.R.A.S., Gresham Professor in Astronomy, will deliver a course of four Lectures entitled "Fact-finding in Astronomy" on Monday to Thursday, May 29 to June 1, at Gresham College, Basinghall Street, E.C.2. Tel. MONarch 2433.—The Lectures are free and begin at 5.30 p.m.

PLYMOUTH AND DEVONPORT TECHNICAL COLLEGE

TAVISTOCK ROAD, PLYMOUTH

DEPARTMENTS OF

SCIENCE AND PHARMACY

FULL-TIME COURSES

1. **B.Sc. GENERAL (PURE SCIENCE)** University of London External—3 years.

Combinations of following subjects are offered:
Chemistry, Physics,
Mathematics, Botany,
Zoology, Geology.

Entry Qualifications: Two Advanced Level passes and three Ordinary Level passes in appropriate subjects.

OR: Three Advanced Level passes and one Ordinary Level pass in appropriate subjects.

2. **GRADUATESHIP OF ROYAL INSTITUTE OF CHEMISTRY**

Entry Qualifications: Advanced Level Chemistry and Ordinary Level passes in English Language, Mathematics and three other subjects.

3. **G.C.E. ADVANCED LEVEL**—2 years.

The following subjects can be taken:
Chemistry,
Pure Mathematics,
Botany,
Geography,
Physics,
Applied Mathematics,
Zoology,
Geology.

Entry Qualifications: G.C.E. Ordinary Level in appropriate subjects.

4. **FINAL PHARMACEUTICAL CHEMIST DIPLOMA**—3 years.

Entry Qualifications: Advanced Level passes in Chemistry, Physics and one of Biology or Botany or Zoology.

Ordinary Level passes in English Language, Mathematics and a Foreign Language.

Particulars and application forms from the COLLEGE REGISTRAR.

UNIVERSITY COLLEGE, LONDON

BIOCHEMICAL ENGINEERING

A one-year postgraduate course leading to a College Diploma is starting on October 2, 1961, suitable for men with degree in chemical engineering, biochemistry, or other associated subjects. The syllabus deals specially with theoretical and practical aspects of food and pharmaceutical manufacture, and is intended for those wishing to take responsible positions in these industries, either in direct management or development.

Inquiries to Professor M. B. Donald, Department of Chemical Engineering, University College London, Gower Street, W.C.1.

UNIVERSITY OF LONDON: A LECTURE entitled "The Reactions in Aromatic Biosynthesis" will be delivered by Dr. D. B. Sprinson (Columbia) at 5 p.m. on May 31 at University College, Gower Street, W.C.1. Admission free, without ticket.—James Henderson, Academic Registrar.

GRANTS & SCHOLARSHIPS

UNIVERSITY COLLEGE OF NORTH STAFFORDSHIRE

DEPARTMENT OF PHYSICS—RESEARCH STUDENTSHIPS AND ASSISTANTSHIPS

A variety of research Studentships and Assistantships are vacant in Physics Department for students completing first degree this Summer. Three main research groups within department with total of 18 postgraduate students at present. Main research interests: (1) Magnetic resonance studies of the solid state including work at very low temperatures; (2) Investigations of gas discharges with particular reference to surface effects. This work is particularly concerned with application of ultra-high vacuum techniques to gas discharges. (3) Studies on strength of glass and similar fibres with particular reference to effect of surface impurities and other defects. Some smaller research groups are studying oxide cathodes and liquid metals at infra-red frequencies.

Further particulars of research studentships available for work in these fields can be obtained from Professor D. J. E. Ingram, Department of Physics, the College, Keele, Staffs.

UNIVERSITY COLLEGE OF NORTH STAFFORDSHIRE

Applications invited for Research Studentship in organic chemistry, value £425 per annum (plus fees), provided by Smith, Kline and French Ltd. The successful candidate will work for a higher degree under supervision of Dr. G. Jones, on heterocyclic syntheses in aza-steroid field.

Applications, together with names of two referees, should reach the Registrar, the College, Keele, Staffs, not later than June 17, 1961.

UNIVERSITY COLLEGE OF NORTH STAFFORDSHIRE

DEPARTMENT OF CHEMISTRY

ALBRIGHT AND WILSON RESEARCH STUDENTSHIP

This Research Studentship, value £425 per annum plus fees for two or three years, is available for thermochemical research on phosphorus compounds, leading to M.Sc. or Ph.D. degree under supervision of Dr. C. T. Mortimer.

Applications from graduates or prospective graduates in chemistry or physics should be sent before July 1, 1961, to the Registrar, the College, Keele, Staffs, from whom further particulars may be obtained.

UNIVERSITY COLLEGE OF NORTH STAFFORDSHIRE

DEPARTMENT OF CHEMISTRY

INSTITUTE OF PETROLEUM RESEARCH STUDENTSHIP

This Research Studentship, value £425 per annum plus fees for two or three years, is available for thermochemical research in cyclic hydrocarbons and heterocyclic compounds, leading to M.Sc. or Ph.D. degree under supervision of Dr. C. T. Mortimer.

Applications from graduates or prospective graduates in chemistry or physics, should be sent before July 1, 1961, to the Registrar, the College, Keele, Staffs, from whom further particulars may be obtained.

UNIVERSITY OF MANCHESTER

METROPOLITAN-VICKERS POSTGRADUATE BURSARIES

Applications are invited from honours graduates in Engineering, Physics, or Mathematics for a number of postgraduate bursaries of a value normally within the range of £350 to £700 per annum, although this maximum may be exceeded in certain cases. The bursaries are tenable for research and advanced study in the Departments of Electrical and Mechanical Engineering in the Faculty of Science or of Technology.

Applications, naming the Department and Faculty in which the candidate proposes to work, should be sent not later than July 1, 1961, to the Registrar, the University, Manchester, 13, from whom further particulars and forms of application may be obtained.

UNIVERSITY OF MANCHESTER

RESEARCH STUDENTSHIPS IN SCIENCE

Applications are invited for the above studentships, normally tenable for three years and of a value comparable to that of a D.S.I.R. Research Studentship. Candidates must hold the degree of Bachelor or Master of a British University other than Manchester.

Applications should be sent not later than July 1, 1961, to the Registrar, the University, Manchester 13, from whom further particulars and forms of application may be obtained.

UNIVERSITY OF SOUTHAMPTON

Chemistry Department. Research Studentship in Organic Chemistry. Up to £400 a year for candidate for higher degree.

Applicants (Honours degree or G.R.I.C.) should send details of career and qualifications, and names of two referees, to Professor R. C. Cookson, The University, Southampton.

MISCELLANEOUS

MURDOCH TRUST

For the BENEFIT of INDIGENT BACHELORS and WIDOWERS of good character, over 55 years of age, who have done "something" in the way of promoting or helping some branch of Science.

Donations or pensions may be granted to persons who comply with these conditions.

For particulars, apply to MESSRS. SHEPHERD & WEDDERBURN, W.S., 16 Charlotte Square, Edinburgh, 2.

STAFFORDSHIRE COUNTY COUNCIL EDUCATION COMMITTEE

SUPPLIES DEPARTMENT

Tenders are invited for the supply of Optical Equipment for Physics Laboratory (Category K.1) for the new College of Technology, Stafford.

Forms of Tender may be obtained from the Director of Education (Supplies), County Education Offices, Earl Street, Stafford. Completed Tenders, enclosed in the envelope provided, must be received by the undersigned at County Buildings, Martin Street, Stafford, not later than noon, Saturday, June 24, 1961.

T. H. EVANS,
Clerk of the County Council.

CYGNET meets the demands of science

The Associated Feed Manufacturers Research Laboratory, York Road, Belfast, is an excellent example of the top quality research accommodation now being provided for industry. Once again, Cygnet Laboratory Furniture provides the supreme craftsmanship and advanced design necessary for maximum efficiency.

Architects: Munce & Kennedy, A.A.R.I.B.A.
Architects & Consultant Engineers,
University Street, Belfast, 7

CYGNET JOINERY LTD · HIGHER SWAN LANE · BOLTON · TEL: BOLTON 62121 (10 lines)

NATURE

THE LEADING INTERNATIONAL JOURNAL OF SCIENCE

Published Weekly Two Shillings and Sixpence

★

"NATURE" surveys the whole field of pure and applied science, and is authoritative and topical. It is read by scientific workers all over the world.

★

Every issue includes

A LEADING ARTICLE—on science in relation to modern life and public affairs.
REVIEWS—each by an authority on the subject discussed.
GENERAL ARTICLES—surveying new discoveries and developments.
NEWS and VIEWS—on current topics and events.
DESCRIPTIVE REPORTS—of scientific meetings.
LETTERS TO THE EDITORS and SPECIAL ARTICLES—in which scientific workers of all countries of the world describe their current investigations.

A classified list of recent Scientific and Technical Books is included each month.

★

The charges for direct postal subscriptions, postage paid to any part of the world, are

12 months	£8 8 0
6 months (26 issues)	£4 4 0
3 months (13 issues)	£2 2 0

Please send me "NATURE" for .... months, beginning with the issue for .....

for which I enclose remittance value .....

Name .....

Address .....

.....

.....

Date .....

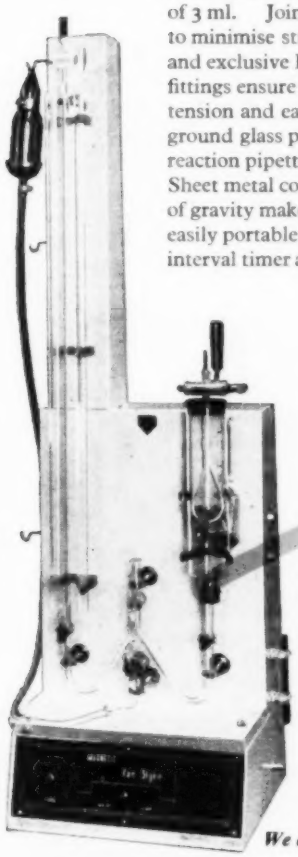
MACMILLAN & CO. LTD., St. Martin's Street, London, W.C.2

Van Slyke

apparatus

WITH MAGNETIC STIRRING

The chief feature of the new B.T.L. Van Slyke Manometric Gas Analysis Apparatus is the variable-speed magnetic stirring, controllable and efficient down to volumes of 3 ml. Joints are spherically ground to minimise strain during dismantling, and exclusive B.T.L. 'Lee' stopcock fittings ensure free rotation, constant tension and easy removal. An illuminated, ground glass panel is fitted behind the reaction pipette for easy observation. Sheet metal construction and a low centre of gravity make the apparatus stable and easily portable. Models with and without interval timer are available.

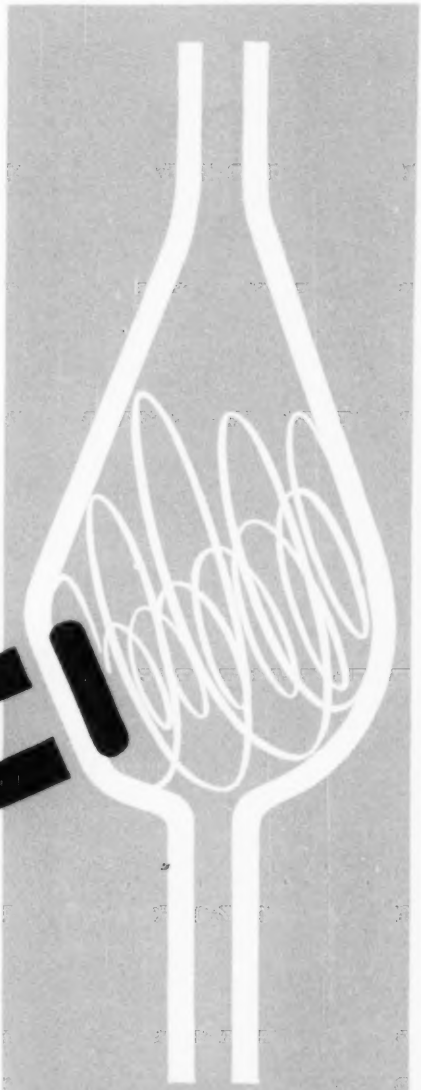


Catalogue No. D6/307 £73.10.0
(without timer)

Catalogue No. D6/308 £85.0.0
(with timer)

Send for full details.

We are exhibiting at ACHEMA



For determination of blood gases and a variety of non-biochemical applications.

BTL

complete laboratory service

BAIRD & TATLOCK (LONDON) LTD., CHADWELL HEATH, ESSEX, ENGLAND

Branches in London, Manchester & Glasgow

Agents throughout U.K. and all over the world

TAS/BT.75

SIMA

a unique source of INFORMATION on scientific instruments

There are two kinds of knowledge; knowing and 'knowing where to find out'. With science and technology developing so rapidly no one can hope to be fully informed on every worthwhile new technique or new equipment.

Here are three ways in which 'knowing where to find out' can help you:

(1) If you already know the answer to your problem but don't know who makes the most suitable equipment SIMA can tell you.

(2) If the answer to your problem depends on whether someone has already developed suitable equipment, SIMA will know if it exists and can tell you where to get it.

(3) If you just have a problem, SIMA can often tell you whether someone has already found the answer to it and has developed equipment to meet it.

Where do SIMA get their information?

From two sources. One is The British Scientific Instrument Research Association (BSIRA) which is constantly engaged in research and maintains extremely comprehensive libraries and files. The other is the membership, consisting of over 180 companies engaged in all these fields of instrumentation:

OPTICAL & OPHTHALMIC	LABORATORY & ANALYTICAL
ELECTRONIC & NUCLEONIC	MEDICAL & X-RAY
ENGINEERING & INDUSTRIAL	KINEMATOGRAPHIC
NAVIGATIONAL & SURVEY	PROCESS CONTROL & AUTOMATION

The Scientific Instrument Manufacturers' Association could be your most valuable source of such information and you will find them very helpful on *any* question about scientific instruments.

the SIMA enquiry service

Over 180 manufacturers with one address

SCIENTIFIC INSTRUMENT MANUFACTURERS' ASSOCIATION OF GREAT BRITAIN

20, QUEEN ANNE STREET, LONDON, W.1.

Telephones—Secretariat Langham 4251 *Enquiry Service Imperial* 6000

Space donated by member: **C. BAKER INSTRUMENTS LTD.** Makers of Optical Instruments

Printed in Great Britain by Fisher, Knight & Co., Ltd., The Gainsborough Press, St. Albans, and published by Macmillan & Co., Limited, at St. Martin's Street, London, W.C.2, and St. Martin's Press, Inc., 175 Fifth Avenue, New York 10, N.Y., U.S.A.—Saturday, May 27, 1961.